Air Force
Instructions

The Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is responsible for the implementation and management of the Air Force SBIR Program. The Air Force Program Manager is Mr. Steve Guilfoos, 1-800-222-0336. For general inquires or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (1 Oct through 1 Dec), contact the Topic Authors listed for each topic on the website. For information on obtaining answers to your technical questions during the formal solicitation period (2 Dec through 15 Jan), go to http://www.acq.osd.mil/sadbu/sbir/solicitations/sitis.htm.

The Air Force SBIR Program is a mission-oriented program that integrates the needs and requirements of the Air Force through R&D topics that have military and commercial potential. Information can be found at the following website: **http://www.afrl.af.mil/sbir/index.htm.**

PHASE I PROPOSAL SUBMISSION:

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. For the Air Force, the contract period of performance for Phase I shall be nine (9) months, and the award shall not exceed $100,000. We will accept only one cost proposal per topic proposal and it must address the entire nine-month contract period of performance.

The Phase I award winners must accomplish their primary research during the first six months of the contract. This primary research effort alone, is used to determine whether the Air Force will request a Phase II proposal. We anticipate no more than 80% of the total cost should be expended within the first six months. After the first six months, additional related research should further the Phase I effort and put the small business in a better position to start Phase II, if awarded. The last three months of the nine-month Phase I contract will provide project continuity for all Phase II award winners so no modification to the Phase I contract should be necessary. Phase I proposals have a 25 page-limit (excluding Company Commercialization Report). The Air Force will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document.

NEW REQUIREMENT: ALL PROPOSAL SUBMISSIONS TO THE AIR FORCE PROGRAM MUST BE SUBMITTED ELECTRONICALLY.

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **5:00pm EST, 15 January 2003 deadline.** A hardcopy **will not** be required. Signatures are not required at proposal submission when you submit your proposal over the Internet. If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

Acceptable Format for On-Line Submission: All technical proposal files must be in Portable Document Format (PDF) for evaluation purposes. The Technical Proposal should include all graphics and attachments but should not include the Cover Sheet or Company Commercialization Report (as these items are completed separately). Cost Proposal information should be provided by completing the on-line Cost Proposal form and including the itemized listing (a-h) specified in the Cost Proposal section later in these instructions. This itemized listing should be placed as the last page(s) of the Technical Proposal Upload. (Note: Only one file can be uploaded to the DoD Submission Site. Ensure that this single file includes your complete Technical Proposal and the additional cost proposal information.)

Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD solicitation. However, your cost proposal will only count as one page and your Cover Sheet will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in submitting your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk.

The Air Force recommends that you complete your submission early, as computer traffic gets heavy near the solicitation closing and slows down the system. **Do not wait until the last minute.** The Air Force will not be responsible for proposals being denied due to servers being "down" or inaccessible. Please assure that your e-mail address listed in your proposal is current and accurate. By the end of January, you will receive an e-mail serving as our acknowledgement that we have received your proposal. The Air Force cannot be responsible for notifying companies that change their mailing address, their e-mail address, or company official after proposal submission.

KEY PERSONNEL:

Identify key personnel who will be involved in this project, including information on directly related education and experience. A resume of the principle investigator, including a list of publications, if any, must be included. Resumes of proposed consultants, if any, are also useful. Consultant resumes may be abbreviated. **Please identify any foreign nationals you expect to be involved in this project, as a direct employee, subcontractor, or consultant. Please provide resumes, country of origin and an explanation of the individual's involvement.**

COST PROPOSAL:

The cost proposal must be at a level of detail that would enable Air Force personnel to determine the purpose, necessity and reasonability of each cost element. Provide sufficient information on how funds will be used if the contract is awarded. Include any additional cost proposal information at the end of your technical proposal. The additional cost proposal information will not count against the 25 page limit.

a. Special Tooling and Test Equipment and Material: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness of the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the government and relate directly to the specific effort. They may include such items as innovative instrumentation and / or automatic test equipment.

b. Direct Cost Materials: Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, price and where appropriate, purposes.

c. Other Direct Costs: This category of costs includes specialized services such as machining or milling, special testing or analysis, costs incurred in obtaining temporary use of specialized equipment. Proposals, which include leased hardware, must provide an adequate lease vs. purchase justification or rational.

d. Direct Labor: Identify key personnel by name if possible or by labor category if specific names are not available. The number of hours, labor overhead and / or fringe benefits and actual hourly rates for each individual are also necessary.

e. Travel: Travel costs must relate to the needs of the project. Break out travel cost by trip, with the number of travelers, airfare, per diem, lodging, etc. The number of trips required, as well as the destination and purpose of each trip. Recommend budgeting at least one (1) trip to the Air Force location managing the contract.

f. Cost Sharing: Cost sharing is permitted. However, cost sharing is not required, nor will it be an evaluation factor in the consideration of a proposal. Please note that cost share contracts do not allow fees.

g. Subcontracts: Involvement of university or other consultants in the planning and / or research stages of the project may be appropriate. If the offeror intends such involvement, described in detail and include information in the cost proposal. The proposed total of all consultant fees, facility leases or usage fees and other subcontract or purchase agreements may not exceed 50% of the total contract price or cost, unless otherwise approved in writing by the contracting officer.

(NOTE): The Small Business Administration has issued the following guidance:
" Agencies participating in the SBIR Program will not issue SBIR contracts to small business firms that include provisions for subcontracting any portion of that contract award back to the originating agency or any other Federal Government agency, including Federal Funded Research and Development Centers (FFRDCs)."

Support subcontract costs with copies of the subcontract agreements. The supporting agreement documents must adequately describe the work to be performed (i.e. cost proposal). At the very least, a statement of work with a corresponding detailed cost proposal for each planned subcontract.

h. Consultants: Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required and hourly rate.

FAST TRACK:

Detailed instructions on the Air Force Phase II program and notification of the opportunity to submit a FAST TRACK application will be forwarded to all Phase I awardees by the awarding Air Force organization at the time of the Phase I contract award. The Air Force encourages businesses to consider a FAST TRACK application when they can attract outside funding and the technology is mature enough to be ready for application following successful completion of the Phase II contract.

For FAST TRACK applicants, should the outside funding not become available by the time designated by the awarding Air Force activity, the offeror will not be considered for any Phase II award. FAST TRACK applicants may submit a Phase II proposal prior to receiving a formal invitation letter. The Air Force will select Phase II winners based solely upon the merits of the proposal submitted, including FAST TRACK applicants.

PHASE II PROPOSAL SUBMISSIONS:

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees that are **invited** to submit a Phase II proposal and all FAST TRACK applicants will be eligible to submit a Phase II proposal. The awarding Air Force organization will send detailed Phase II proposal instructions to the appropriate small businesses. Phase II efforts are typically two (2) years in duration and not exceed $750,000. (NOTE) All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system.

All Phase II proposals must have a complete electronic submission. **COMPLETE** electronic submission includes the submission of the Cover Sheet, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal and any appendices via the DoD submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Your proposal **must** be submitted via the submission site on or before the Air Force activity specified deadline. Phase II proposal submission is limited to 75 pages. Phase II Cost Proposal information should be provided by completing the on-line Cost Proposal form and including the itemized listing (a-h) specified in the Cost Proposal section earlier in these instructions. This itemized listing will not count against the page limitation and should be placed as the last page(s) of the Technical Proposal Upload. (Note: Only one file can be uploaded to the DoD Submission Site. Ensure that this single file includes your complete Technical Proposal and the additional cost proposal information.)

AIR FORCE PHASE II ENHANCEMENT PROGRAM

On active Phase II awards, the Air Force will select a limited number of Phase II awardees for the Enhancement Program to address new unforeseen technology barriers that were discovered during the Phase II work. The selected enhancements will extend the existing Phase II contract award for up to one year and the Air Force will match dollar-for-dollar up to $250,000 of non-SBIR DoD matching funds. Contact your local organizational SBIR Manager for more information.

AIR FORCE PROPOSAL EVALUATIONS

Evaluation of the primary research effort and the proposal will be based on the scientific review criteria factors (i.e., technical merit) and other criteria as discussed in this solicitation document. Please note that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror. The Air Force anticipates that pricing will be based on adequate price competition.

> NOTICE: Only government personnel will evaluate proposals. However, Air Force support contractors may be used to administratively process or monitor contract performance and testing. Any contract award may require a nondisclosure agreement between Air Force support contractors and awarded small businesses.

AIR FORCE SBIR PROGRAM MANAGEMENT IMPROVEMENTS

The Air Force reserves the right to modify the submission requirements. Should the requirements change, all Phase I awardees that are invited to submit Phase II proposals will be notified. The Air Force also reserves the right to change any administrative procedures at any time that will improve management of the Air Force SBIR Program.

AIR FORCE SUBMISSION OF FINAL REPORTS

All final reports will be submitted to the awarding Air Force organization. Companies **should not** submit final reports directly to the Defense Technical Information Center (DTIC).

PHASE I PROPOSAL SUBMISSION CHECKLIST

Failure to meet any of the criteria will result in your proposal being **REJECTED** and the Air Force will not evaluate your proposal.

1) The Air Force Phase I proposal shall be a nine month effort and the cost shall not exceed $100,000.

2) The Air Force will accept only those proposals submitted electronically via the DoD SBIR website (www.dodsbir.net/submission).

3) You must submit your Company Commercialization Report electronically via the DoD SBIR website (www.dodsbir.net/submission).

> NOTE: Even if your company has had no previous Phase I or II awards, you must submit a Company Commercialization Report. Your proposal will not be penalized in the evaluation process if your company has never had any SBIR Phase Is or IIs in the past.

PROPOSAL/AWARD INQUIRIES

We anticipate having all the proposals evaluated and our Phase I contract decisions by mid-May. All questions concerning your proposal and its disposition MUST be directed to the Air Force organization (AFRL Technology Directorate or Center) where you submitted your proposal. Organizations and their Topic numbers are listed in the front of the Air Force Topic section of this solicitation.

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF03-001 thru AF03-011	Directed Energy Directorate AFRL / DE 3600 Hamilton Ave. SE Kirtland AFB NM 87117-5776	Robert Hancock (505) 846-4418	Dave Tuttle (505) 846-8133
AF03-015 thru AF03-033 AF03-037	Space Vehicles Directorate AFRL / VS 3600 Hamilton Ave. SE Kirtland AFB NM 87117-5776	Robert Hancock (505) 846-4418	Francisco Tapia (505) 846-5021
AF03-041 thru AF03-065 AF03-069	Human Effectiveness Directorate AFRL / HE 2610 Seventh St. Bldg. 441 Rm 216 Wright-Patterson AFB, OH 45433-7901	Sabrina Davis (937) 255-2423 Ex. 226	Mary Jones (937) 255-2527
AF03-075 thru AF03-101 AF03-103	Information Directorate AFRL / IF 26 Electronic Parkway Rome, NY 13441-4514	Janis Norelli (315) 330-3311	Joetta Bernhard (315) 330-2308
AF03-109 thru AF03-126	Materials & Mfg. Directorate AFRL / ML 2977 P St. Suite 13 Bldg. 653 Wright-Patterson AFB, OH 45433-7746	Marvin Gale (937) 255-4839	Terry Rogers (937) 656-9001
AF03-129 thru AF03-148 AF03-151	Munitions Directorate AFRL / MN 101 West Eglin Blvd. Suite 140 Eglin AFB, FL 32542-6810	Dick Bixby (850) 882-8591 x 1281	Selesta Carol Abbott (850) 882-4294 x3414
AF03-157 thru AF03-178	Propulsion Directorate AFRL / PR 1950 Fifth St. Bldg. 18 Wright-Patterson AFB, OH 45433-7251	Laurie Regazzi (937) 255-1465	Susan Day (937) 255-5499

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF03-182 thru AF03-187	AFRL / PRO 5 Pollux Drive Edwards AFB, CA 93524-7033	Debbie Spotts (661) 275-5617	Donna Thomason (661) 277-8596
AF03-188 thru AF03-230	Sensors Directorate AFRL / SN 2241 Avionics Circle, Rm N2S24 Bldg. 620 Wright-Patterson AFB, OH 45433-7320	Marleen Fannin (9370 255-5285 Ex. 4117	Sharma Wilkins (937) 255-4279
AF03-233 thru AF03-239	Air Vehicles Directorate AFRL / VA 2130 Eighth St. Bldg. 45 Wright-Patterson AFB, OH 45433-7542	Madie Tillman (937) 255-5066	Douglas Harris (937) 255-3427
AF03-242 thru AF03-248	Air Armament Center 46 TW / XPP 101 West D Ave. Suite 222 Bldg. 1 Eglin AFB, FL 32542-5492	John Miller (850) 882-6767	Lorna Tedder (850) 882-4141 Ex.4557
AF03-251 thru AF03-257	Arnold Engineering Dev. Center AEDC / DOT 1099 Avenue C Arnold AFB, TN 37389-9011	Ron Bishel (931) 454-7734	Kathy Swanson (931) 454-4409
AF03-260 thru AF03-268	Air Force Flight Test Center AFFTC / XPDT 307 East Popson Avenue Bldg.1400 Rm 107A Edwards AFB, CA 93524-6843	Abraham Atachbarian (661) 277-5946	Donna Thomason (661) 277-8596
AF03-269 thru AF03-275	Oklahoma City Air Logistic Center 3001 Staff Drive, Suite 2AG70A Tinker AFB, OK 73145-3040	Lt. Michael Brewer (405) 736-3197	David Cricklin (405) 739-4468

Topic Number	Activity	Program Manager	Contracting Authority (for contract question only)
AF03-279 thru AF03-284	Ogden Air Logistic Center 5851 F Avenue Bldg. 849, Rm A-15 Hill AFB, UT 84056-5713	Joseph Burns (801) 586-2721	Paulette Crowell (801) 775-2365
AF03-287 thru AF03-293	Warner Robins Air Logistic Center 420 Richard Ray Blvd., Suite 100 Robins AFB, GA 31098-1640	Jamie McClain (478) 926-6617	Nita Steinmetz (478) 926-3695

AirForce 03.1 Topic List

AF03-001	Space Qualifiable High Energy Laser Deformable Mirror
AF03-002	High Power, High Efficiency Optical Power Amplifiers
AF03-003	Thresholdless High-gain Optical Phase Conjugation (OPC) Mirror for Remote Object Laser Tracking
AF03-004	Space Qualified One Micron Lasers
AF03-005	Active Optical Remote Sensing System for Ground Contamination Detection
AF03-006	High-Energy Laser Coatings for Large, Lightweight, and Compliant Deployable Space Optics
AF03-007	High Power Short Pulse Transmit/Receive Isolation Device
AF03-008	Pulsed Solid State Laser Illuminators for Tactical Air Platforms
AF03-009	Spatially Modulated Reflective Membranes for High-Dynamic-Range Wavefront Control
AF03-010	Narrow Band High Power Antennas for Airborne Platforms
AF03-011	High Power Mid-Infrared (2-10 Micron) Diode Laser Development
AF03-015	Innovative Measurement Techniques for Space-Based Remote Sensing/Standoff Detection
AF03-016	Long-term Ionospheric Forecasting System
AF03-018	Small Vehicle Launch Technology
AF03-019	Common Aero Vehicle Payload and Avionics Isolation
AF03-020	Fine Steering Mirrors for Free Space Optical Communication Systems
AF03-021	Precision Control of Fast Steering Mirrors for Laser Communications
AF03-022	Efficient Electro-optical Modulators for Microwave/Photonic Intra-satellite Links
AF03-023	Optical Network Devices and Protocols for Space
AF03-024	Infra-red Avalanche Photodiode Detectors (APD) for Laser Communications
AF03-025	Multibeam Optical Communications Transmitter/Receiver
AF03-026	Millimeter Wave, Low Noise Amplifier
AF03-027	Space Qualifiable Beam Control Driver Electronics
AF03-028	Nano/Micro Technologies for Particle Sensing in the Space Environment
AF03-029	Small Satellite Bus Technologies
AF03-030	Integrated MEMS Switch Packages for Space Systems and Communications Architectures
AF03-031	Polarization Phenomenology

AF03-032	High Specific Power Solar Arrays from Nanoparticle Precursors
AF03-033	Solar Thermal Technologies for Orbit Transfer Vehicles and Space Mobility
AF03-037	Autonomous Satellite Cluster Data Fusion
AF03-041	Integrated Aircrew Ensemble
AF03-042	Improved Low-Cost Helmet-Mounted Display for Mission Simulations
AF03-043	Simple 3-D Target Recognition and Identification
AF03-044	Personnel Torso Thermo Cooler System
AF03-045	Personal Computer (PC)-Based Aircraft Training System and Visualization Tool
AF03-046	A New Display Paradigm for Air Traffic Control Management
AF03-047	Integrated Cognitive Architectures for the Joint Synthetic Battlespace
AF03-049	Wireless HMD data transmittance
AF03-050	Displaying Tailored Real-time Information in Multi-Crew Cockpits
AF03-051	Variable Transmittance HMD Visor
AF03-052	Intelligent Scenario Generation Tools for Training and Rehearsal
AF03-053	Time Critical Targeting Training and Rehearsal Environment
AF03-054	Body Worn Graphic Image Generator for Simulator Based Training
AF03-055	Deployment Survivability for Mobile Ground Stations
AF03-056	Messaging System Simulation for Space Operations
AF03-057	Attitude Control System Simulation
AF03-058	Simulation Models for Satellites
AF03-059	Through Screen Optical Head Tracker
AF03-060	Command and Control Interfaces for Virtual Teams
AF03-061	Multisensory Integration for Pilot Spatial Orientation
AF03-062	Stand-off Detection of Biological Warfare Agents by Laser-induced Breakdown Spectroscopy (LIBS)
AF03-063	Personnel Real-time Operational Toxic Exposure Characterization Tool (PROTECT)
AF03-064	Simulation and Training Development to Enhance the Tactical Knowledge and Readiness of Information Warfare Teams
AF03-065	Destruction of Chemical/Biological Warfare Agents using a Portable Microwave Emitter

AF03-069	Head Mounted Miniature Display
AF03-075	Automated Mission Planning Tools for Simulation Based Acquisition (SBA) of C2 Systems
AF03-076	Millimeter Wave Communications for Force Protection
AF03-077	Application of Wireless Communications for Transfer of Cryptographic Key Material
AF03-078	Commercialization of Software Model Architecture Visualization Tool
AF03-079	Multiple Security Level Collaboration
AF03-080	Component Generation And Integration For The ESC Scheduler Product Line
AF03-081	Object-oriented Concurrent Distributed Engineering, Development, and Operations
AF03-082	TCP/IP Addressing Concepts for Deployed Users
AF03-083	GPS Spaceborne High Efficiency, Jam-resistant Satellite Crosslinks
AF03-084	Data Fusion Algorithms Development
AF03-085	Passive Communication Options for Miniature Satellites
AF03-086	Hyperspectral Visualization & Spectral Exploitation (HyperVISE)
AF03-087	Low Loss/Low Cost Phase Shifters
AF03-088	V-band Traveling Wave Tube Amplifier
AF03-089	Improved Synthetic Aperture Radar Quality
AF03-090	Multi-Intelligence (INT) Fusion to Augment Track Continuity and Provide ID
AF03-091	Space Based Radar (SBR) Space Time Adaptive Processing (STAP)
AF03-092	Space Based Radar (SBR) Bistatic Space Time Adaptive Processing (STAP)
AF03-094	Innovative Information System Technologies
AF03-095	Cross-domain user identity and credential management
AF03-096	Force Templates for Assimilating Unit Infospheres
AF03-097	Indications and Warnings for Homeland Defense
AF03-098	IA Technologies for Mobile Users
AF03-099	Effects-Based Counter Terrorism Operations
AF03-100	Multi-Organizational Collaboration and Decision Support for Emergency Preparedness
AF03-101	Multi-Band Antenna Technology
AF03-103	Gateway Interface for C4ISR Platforms and their Assets

AF03-109	Improved Protective Coatings for High Strength Steels
AF03-110	Low Cost Replacement for Current Screen Technology
AF03-111	Extended Life Corrosion Protection
AF03-112	Improved Life Prediction of Turbine Engine Components
AF03-113	Conductive Repair Coatings
AF03-114	High Speed Forging of Titanium Components with Microstructural Control
AF03-115	Thermal Barrier Coatings for Titanium and High Temperature Polymeric Composite Components
AF03-116	Repair of HighTemperature RAM Coatings
AF03-117	Modeling of Laser Additive Manufacturing Processes
AF03-118	Enhanced Strength Aerospace Carbon Foam Heat Exchanger
AF03-119	Gas turbine engine oil additives for advanced bearings - advanced steels
AF03-120	Determination of Micorcracking Damage in Composites
AF03-121	Filter for Airborne Pathogens and Toxic Liquids
AF03-122	Novel Flame and Impact Resistant Foam Core
AF03-123	Hidden Threat Detection Techniques
AF03-124	Window Materials for Airborne Directed Energy Applications
AF03-125	Narrow Band, High Reflectivity Optical Elements in the Infrared
AF03-126	Durable Hybrid Thermal Protection System
AF03-129	Inductively Coupled Initiation Systems
AF03-130	Optical Initiation of Explosives
AF03-131	Efficient Propulsion for Long Loiter Tactical Mini Air Vehicles
AF03-133	High Lift-to-Drag Airframes for Long Loiter Tactical Mini Air Vehicles
AF03-134	Adaptive Missile Airframe Technology
AF03-137	Free Flight Sensor
AF03-138	Bistatic Altimeter Concept
AF03-139	Precise Guidance--No Seeker
AF03-140	Airframe Materials for High Speed Tactical Missiles
AF03-141	Rapid Target Failure Modes, Effects and Criticality Analysis

AF03-142	Revolutionary Beam Steering Technology for Imaging Laser Radar
AF03-143	Munitions Research
AF03-144	Readout Integrated Circuit Development for Staring Focal Plane Array Laser Radar (LADAR)
AF03-145	Micro-Encapsulation Of Nanometric Reactive Particle Mixtures With Explosive Cores
AF03-146	Material Characterization of Chemical and Biological Agents
AF03-147	Modeling Damaged Agent Filled Containers with Incompressible Turbulent Flow and Moving Boundaries
AF03-148	Creative Robots to Defeat Deeply Buried Targets
AF03-151	Soft Landing Capability For 1000 lb Dispenser
AF03-157	Enhanced Circuit Protection and Safety via Arc Fault Circuit Interrupters for Military/Commercial Aircraft
AF03-158	Oil-free Bearing Technologies for Aerospace Power Systems
AF03-160	Health Monitoring for the Integrity of Electrical Power Wiring and Power System Components
AF03-161	Technologies for Elimination of Hyrdazine in Aerospace Power
AF03-162	Nonflammable Lithium-ion Battery Electrolytes Capable of Extended Operational Temperature Ranges
AF03-163	High Current (40 to 100 amp) Solid-State Power Control (SSPC) Technology
AF03-164	Application of Microsystem Technologies in Advanced Aerospace Vehicle Power Systems
AF03-166	Engine Acoustic/Screech Sensor
AF03-167	T4.1 Gas Path Sensor Technology
AF03-168	Enhancing Engine Operating Envelope by Ignition and Lean Blowout Modeling and Simulation
AF03-169	FMECA / EHM System Design Technology
AF03-171	Intelligent/Virtual Rotor Bearing System and Design Through Modeling and Simulation
AF03-172	Advanced Separator Materials For Batteries
AF03-173	Aero Propulsion and Power Technology
AF03-174	Turbine Engine Weight/Maintenance Reduction and Reliability Improvement via Fluidic Controlled Inlet Guide Vanes (IGVs) and Stators
AF03-175	Spray Cooling in Micro-gravity Applications
AF03-176	Supersonic Combustion Transient Analysis and Control
AF03-177	Package and Personnel Inspection Systems for Installation and Aviation Security

AF03-178	Oil Free Rotor Support for Small Turbine Engines
AF03-182	Deployable, Membrane Optical or RF Reflector,
AF03-183	Improved Specific Strength Materials for Rocket Motor Case Weight Reduction
AF03-185	Compact High Current Beam Generator
AF03-186	Miniature Satellites Launcher
AF03-187	Tactical Missile Advanced Steering Technology
AF03-188	Directed Beam Infrared Signature Replication of Fighter Aircraft
AF03-189	Single Step Ultratight GPS Acquisition to Navigation
AF03-190	Electromagnetic Compatibility/Interoperability Research Tools For Aging Aircraft COTS Insertion
AF03-191	Missile Warning System Development Simulation Tools For Rapid Technology Insertion
AF03-192	Real-Time High-Fidelity Threat Simulation Capability
AF03-193	Multi-sensor Registration Tools
AF03-196	Space Based Optical Sensor Calibration Approaches
AF03-197	Passive Coherent Location (PCL) for Launch Vehicles
AF03-198	Single-Element Zoom Antenna
AF03-199	Global Positioning System (GPS) Receiver
AF03-200	Miniature Supercooled, Multiarm, Spiral, Antijam Controlled Reception Pattern Antenna (CRPA)
AF03-201	Direct Transition from Acquisition to Ultra-Tightly Coupled GPS/IMU
AF03-202	Adaptive Polarized Array Antennas
AF03-203	Direct Initialization of Ultra-Tightly Coupled Weapons
AF03-204	Multiple Aperture Beam Tracking
AF03-205	GPS Spaceborne High Power/High Efficiency L-Band Sources
AF03-206	Conformal Antenna Material Technology
AF03-207	Wideband Radiating Aperture
AF03-208	EHF Digital Beamforming Array Technology
AF03-209	Advanced W-Band AntennaTechnology
AF03-210	Efficient and compact Electron Sources for Advanced Communication Devices

AF03-211	Innovative Antenna Tracking for Mobile PlatformsS
AF03-212	Representation for Enhanced Sensor Exploitation
AF03-213	Robust Contingency Planning For Multiple ISR Sensors
AF03-214	Active Management of Multiple Sensors & Platforms for Synchronized ISR
AF03-215	Continuous Identification Sensor Management
AF03-216	Combining Unattended Ground Sensor & ISR Information for improved SA
AF03-217	Synthetic Signature Prediction and Feature Analysis for Recognition Applications
AF03-218	Model -Based Algorithms for Confident ATR Using 3d Data
AF03-219	Missile Threat Warning Discrimination
AF03-220	Agile, Detecting and Discriminating, Infrared Electro-Optical Systems (ADDIOS)
AF03-221	Innovative Adaptive Processing Techniques for Wideband and Multi-Band Conformal Arrays
AF03-222	Feature Based Identification and Association
AF03-223	Sensor Suites for UAVs
AF03-224	Innovative Sensors and Algorithms for detection and identification of time critical targets
AF03-227	Precision Targeting
AF03-228	Integrated Sensing and Processing for Continuous Identification
AF03-229	Synthetic Prediction Technologies for Infrared (IR) System Development
AF03-230	GPS Civil Signal Validation Techniques
AF03-233	Flow Control and Plasma Technology for Aerospace Vehicles
AF03-234	Unified Computational Code for Rarefied and Continuum Flight Regimes
AF03-235	Fly-By-Light (FBL) Technologies for Directed Energy Weapon Systems
AF03-236	Cooperative Decision and Control Algorithms with Information Flow Constraints
AF03-237	Future Technology for Aerospace Structures Technology
AF03-238	Aerospace Structures
AF03-239	Small Unmanned Aerial Vehicles (UAVs) for Detection of Agents of Mass Destruction (SUDAMaD)
AF03-242	Variable Pressure High Speed Test Track
AF03-243	Test Range Mobile Relay Platform
AF03-244	Generic, Multi-Platform, Real-Time Data Monitor

AF03-245	Modular Narrow Band RF Generator
AF03-246	Miniature/Sub-miniature Infrared (IR) Camera
AF03-247	Longwave Infrared Focal Plane Array for Imaging Fourier Transform Spectroscopy
AF03-248	Survivability of Aircraft to Terrorist Missile Threats
AF03-251	High-Response Total Temperature Distortion Measurement
AF03-252	Miniature Absolute Pressure Transducer
AF03-253	Computational Toolkit for Generating Missile Signature Databases
AF03-254	Computational Fluid Dynamics (CFD)-Based Test Facility Design System for Reliable and Controlled Flow Quality
AF03-255	Expandable, Intelligent Switchgear Corona Monitoring
AF03-256	Momentum Accommodation Coefficient Measurement Device
AF03-257	Non-intrusive Optical Smoke Meter for Turbine Engines
AF03-260	Multiband Multimode Programmable Telemetry Transmitter
AF03-261	Infrared/Ultraviolet (IR/UV) Background Monitoring System (IRUVBMS)
AF03-262	Wideband Telemetry Over Internet Protocol Networks in Real Time (TM/IP)
AF03-264	PC Based Dynamic Real-Time Infrared Image Generation Capability
AF03-265	Reduction of Arsenic in Water
AF03-266	Simulated Clutter for Airborne Radar Evaluation (SCARE)
AF03-268	Direct Energy Countermeasures Stimulator System (DECSS)
AF03-269	Use of Pattern Recognition to Optimize Site Investigation
AF03-270	Adapting Bar Code Readers to Hand Held Elector-Optical Wiring Inspection Devices
AF03-271	Knowledge Capture and Re-use in Maintenance, Repair, and Overhaul
AF03-272	Use of Electrokinetics to Enhance In-Situ Remediation of Chlorinated Organic Contaminants in Groundwater
AF03-274	Graphical Index for Aircraft Legacy Data
AF03-275	Wireless Asset Tracking, Matching, and Management
AF03-279	Low-Cost Composite Materials/Additives that Provide Resistance to Direct Solar Ultra-Violet (UV) Radiation Deterioration
AF03-280	Ultra High-Resolution Visual System Development

AF03-281	Universal Power Sensing and Control Module
AF03-282	Non-Contact, 3-D Measurement for Aircraft Surfaces
AF03-283	Diesel/JP-8 Reformer for Solid Oxide Fuel Cell (5kW-10kW Advanced Portable Auxiliary Power Unit)
AF03-284	Nanoscale Devices
AF03-287	Advanced DC Power Distribution Module--Convert DC to Aircraft Quality Power
AF03-288	Portable Programmable Load Bank
AF03-289	Advanced Multi-Use Fuel Cell Powered Tactical Vehicle (Tow Tractor) With Distributed Power
AF03-290	High Density Hydrogen Storage
AF03-291	Bio-Mass Waste Water Generator/Gray Water Purifier
AF03-292	Cold Turbine Engine
AF03-293	Advanced Hydrogen Transfer Sensor Research

AF03-001 TITLE: Space Qualifiable High Energy Laser Deformable Mirror

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: Space and Missile Systems Center (SMC)

Objective: Develop a space qualifiable, high dynamic range, high resolution deformable mirror for high energy lasers.

Description: Deformable mirrors can be used to improve the quality of the wavefront of a projected beam or source image, which has been distorted by disturbances along the optical path. One military application is the delivery of a useful photon beam at a distance with good beam quality for illumination or lethality purposes. Improved technology in this area could be readily applied to the design of large aperture relay mirrors for space applications. Similar techniques can be used for commercial applications such as precorrection of the beam in a laser communications system. Deformable mirrors (DMs) can also be used to improve the quality of a distorted image received at a sensor. In addition a great deal of progress has been made in the area of Micro-Electro-Mechanical Systems (MEMS) for use as fast, compact and lightweight DM's. There are both military and commercial uses for such devices in surveillance and for imaging under difficult visual conditions. Both Space Based Laser (SBL) and Airborne Laser Systems (ABL) use deformable mirrors with wavefront sensors and feedback control systems to improve the wavefront quality of the outgoing HEL beams. The innovative challenge lies in almost contradictory requirements of light-weighting the reaction mass and supporting structure while maintaining or bettering the compactness of the actuator controls architecture, maintaining stroke performance with the same or better bandwidth, minimizing hysteresis, increasing spatial resolution and maintaining good thermal management for flight use. This is where a revolutionary technology like MEMS used as a DM, could be used to balance the above contradictory requirements. Flight applications may include the upper atmospheric environment or space vacuum and use under warfighting conditions. In addition, space use dictates surviving the launch environment. Thermal management to maintain optical quality while facilitating efficient heat dissipation may dictate novel materials and assembly techniques. Sensitivity to environmental thermal or humidity changes due to facesheet epoxies call for adhesives or new bonding technique. New facesheet materials and approaches toward higher subaperture densities may be another solution.

Phase I: The respondent shall develop concepts and define the requirements for the design of a new, lightweight, high spatial resolution, flight qualifiable deformable mirror architecture. Ingenuity in design and choice of materials is anticipated. The conceptual design of a prototype to be built and demonstrated in Phase II shall include sufficient number of subapertures and features so that the design features are scalable to a useful full aperture. Some analyses and tests of components may be expected. The designs, a Phase I report, and a proposal for Phase II will be expected products.

Phase II: Detailed design and fabrication of a prototype to be tested is expected. The contractor shall design appropriate characterization and performance tests to evaluate the prototype. These may include optical tests with an HEL beam or its surrogate at an Air Force Research Laboratory, Directed Energy facility. The AFRL/DE directorate has the ability to perform some limited HEL tests at the ABL laser wavelength of 1.3 micrometers. These HEL tests will be done at no cost to the contractor. Scalability of the new design must be demonstrated and sufficient analysis performed to describe techniques for scaling. The final product is a complete test and characterization report of the new technology.

Dual Use Commercialization Potential: An immediate military customer is SBL and other potential customers are other directed energy projects such as ABL. The likely dual use applications of this new deformable mirror technology reside in the imaging sensor, airborne laser communications, and astronomy markets.

Related References:

1. S. Daigneault et al., "ABL Subscale Deformable Risk Reduction Tests", Proc SPIE 3706, p304, 1999.

2. M. Ealey, J. Wellman, "Deformable Mirrors: design fundaments, key performance specifications, and parametric trades", Proc SPIE 1543, p36,
1991.
3. W.C. Marlow, "Dynamics of a Deformable Mirror Actuator", Opt Eng. 33, p1016, 1994.
4. J. D. Mansell, S. Sinha, R. L. Byer, "Adaptive Optics Development for Laser Systems," Proceedings of SPIE, vol. 4493 (2001).

KEYWORDS: Deformable Mirror, High Spatial Frequency, Large Stroke, High Bandwidth, Adaptive Optics, High Energy Laser, Wavefront Correction

AF03-002 TITLE: High Power, High Efficiency Optical Power Amplifiers

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop high power (>10W), high efficiency (> 40% laser power per electrical power input) optical power amplifiers (OPA).

Description: Future high bandwidth satellite communications will utilize free-space lasers. Lasercomm terminals on satellites and terrestrial assets (air and ground, mobile and fixed) will permit high bandwidth, low probability of intercept, and jam resistant communications between satellites (crosslinks), and between satellites and ground/air assets. The data rate and range of these devices is determined by the laser power output, which is limited by the output capability of the laser power amplifier and the efficiency of these devices. By increasing the efficiency and power output of these devices, one could simplify the integration of optical communications devices with spacecraft and terrestrial vehicles, enable much higher data rates, and simplify the optical and pointing control systems. Conventional erbium doped fiber amplifiers (EDFA) and Ytterbium doped fiber amplifiers (Yb-DFA) have been developed exhibiting 28% performance (at 2W) and up to 20W output in a narrow-band single mode fiber. Powers in excess of 100W have been achieved in broadband double-clad Yb fiber lasers (not amplifiers). The goal of this project is to increase output power and efficiency of fiber amplifiers for free space laser communications applications.

Phase I: Identify requirements of optical power amplifiers for space based laser communications, including desirable wavelengths and data rates. Develop materials and approaches to achieve high power output (>10W) and high efficiency (> 30% conversion of electrical power in to laser power output) OPAs for optical communications systems which can be operated in the space environment. Explore alternative dopants, fiber configurations such as dual clad large core fibers, more efficient pump lasers, pump laser wavelengths and coupling techniques, and low loss pump laser filters.

Phase II: Fabricate and test several OPA devices based on the materials and concepts developed in Phase I. Test the devices to determine output and efficiency over a range of operating conditions likely to be required for space based optical communications. Verify noise figure and bandwidth capability.

Dual Use Commercialization Potential: Commercial communications satellite constellations (LEO (Low Earth Orbit), MEO (Medium Earth Orbit), and GEO (Geosynchronous Earth Orbit)) could benefit from a low cost, high power lasercomm terminal that leverages COTS (Commercial Of The Shelf) components. These terminals could support ultra-large bandwidths to provide cost effective global commercial communications. High efficiency OPAs could also be used for fiber communications, reducing thermal control requirements, increasing distance between repeaters, and permitting more bandwidth per fiber in WDMA (Wavelength Division Multiple Access) schemes.

Related References:
1. V. Dominic, et al., “110W Fibre Laser”, Electronic Letters, 35, 14, (1999).
2. S. Hofer, et. al., “Single-frequency master-oscillator fiber power amplifier system emitting 20 W of power,” Optics Letters, Vol. 26, No. 17, (2001) 1326-1328.

KEYWORDS: Laser Communication, Optical Power Amplifier, Fiber Amplifier, Lasers, Crosslinks, Erbium Doped Fiber Amplifiers

AF03-003 TITLE: Thresholdless High-gain Optical Phase Conjugation (OPC) Mirror for Remote Object Laser Tracking

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop extremely low threshold, non-linear optical mirror for efficient laser wave-front conjugation.

Description: Laser tracking, imaging and engaging of a remote diffusely reflecting targets (satellite, high-altitude aircraft, etc.) requires high-energy concentration on the target's surface. This operation was demonstrated for a relatively short remote distance (up to several km) and at low aberration conditions (optically uniform medium) along the tracking pass. However for remote targets (especially high altitude) and deep atmospheric turbulence the need of the efficient energy concentration on the target faces serious challenge. Consequently, a variety of the methods have been proposed and demonstrated for achieving this goal mainly using the unique features of optical phase conjugation. Although all of these methods show promise in some areas, they all have some limitations connected with high threshold requirements of the non-linear medium used for OPC-mirror operation, operating frequency, spectral and spatial resolution. The practical realization of the tracking system requires the OPC-mirror with an ultra low energy level of the signal beam. For an estimate one can expect that the threshold level should be of the order of 10-17 J (or several hundreds of photons) which is practically thresholdless. Alongside with above-mentioned requirement in sensitivity the proposed OPC-mirror should be spectrally selective to prevent amplification of the background noise emission.

Phase I: Develop preliminary concept of the high-gain thresholdless phase conjugate mirror. Select the mechanism of optical non-linearity and the media that can provide optimal operation of such OPC mirror. Analyze and estimate the performance parameters that limit its operation. The development should place emphasis on the operation with Q-switch and free-running laser oscillation, non-linear medium stability and reliability. Experimental investigations should result in selection of the key component of the proposed design of the OPC mirror and define breadboard demonstration of its basic characteristics (high gain and thresholdless operation).

Phase II: Build a proof-of-concept prototype thresholdless OPC-mirror with required parameters. Demonstrate its operation and projected performance with tracking a distance remote moving object through the turbulent atmospheric.

Dual Use Commercialization Potential: There are numerous applications that require or could benefit from the use of scalable high-gain thresholdless OPC-mirror. Both commercial and military remote target tracking needs will benefit from the low cost, small size and high accuracy of optical phase conjugate laser tracking system supported by this technology. This concept could also be applied as an automated landing beacon to passively track and guide aircraft landing, or as the beacon to facilitate satellite contact/communication. It is specially robust for space based satellite operation.

Related References:

1. R.Fisher, "Optical Phase Conjugation", Academic Press, 1983.
2. J.Feinberg, R.Helwarth, Phase-conjugate mirrors with continuous-wave gain", Opt.Lett, v. 5, 519, 1980.
3. M.Glower, D.Proch (Eds.) Optical Phase Conjugation, Springer-Verlag, 1994, p.388.
4. Peper, D.M., Fekete, D., Yariv, A., "Observation of Amplified Phase Conjugate Reflection and Optical Parametrical Oscillation by Degenerate Four-Wave Mixing in Transparent Medium", Appl. Phys. Lett., Vol. 33, No., p. 41, (1978).
5. Mailis, J. Hendricks, D.P. Shepherd, et all, "High-phase-conjugate reflectivity (>800 %) obtained by degenerate four wave mixing", Optics Letters, vol. 24, no 14, p.972-974, (1999).

KEYWORDS: Remote Target Tracking, Accuracy in Centimeters Range, Phase Conjugate Mirror, Atmospheric Optical Aberrations, Nonlinear Medium

AF03-004 TITLE: Space Qualified One Micron Lasers

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: Space (SP)

Objective: Develop space qualified 1-micron solid state lasers for remote sensing, tracking and imaging in space.

Description: The ability to remotely sense, track, and image is desired for a wide range of space-borne applications. The tracking, imaging, and identification of objects near earth, in deep space, on land, and under water, along with the sensing of trace levels of chemical and biological materials are some of the applications requiring special purpose high pulse energy laser systems on space platforms. Unfortunately, many of the existing laser systems that might be suitable for such applications have mass, cooling, power, alignment, maintenance, and other requirements that are incompatible with prolonged unmanned operation in space. Fortunately, a large number of applications can be served well by starting with rugged 1-micron rare earth doped laser systems pumped by efficient, commercially available semiconductor laser diodes. High pulse energy one-micron lasers can be built to produce a wide variety of output pulse formats, and can be frequency converted to generate radiation over a wide wavelength range (UV to mid IR). This SBIR topic seeks proposals to further advance 1-micron solid state laser technology for space applications by utilizing innovative designs to overcome the constraints associated with fielding and operating a laser in the space environment. The current state of the art is less than 10 W average power, as has been pioneered by NASA. The goal of this SBIR program will be to develop laser device concepts that will lead to 1-micron space qualified lasers at the 100 W average power level.

Phase I: The Phase I objective will be to develop a design for a Q-switched 1 micron solid state laser with outputs of 1J/pulse at a repetition frequency of 100Hz. Compelling designs with >250mJ/pulse at >50Hz may also be considered for Phase II funding. The one micron laser design should emphasize reliability, compactness, efficiency, and ruggedness. The mechanical construction, along with the power control and cooling systems should be traceable to a space qualified device. A near diffraction limited (M-squared<1.2) output beam is required. Linearly polarized output beams are preferred, but not essential. Transform limited pulses are not required. The proposed system design must be realizable, in that the key device elements (cooling, output power, efficiency, space environment concerns, etc.), can be demonstrated or reasonably assessed within the scope of a Phase II SBIR contract. Risk reduction tasks that support the design may be carried out in Phase I. The space qualification issues should be considered early in the program so that they can be addressed at a Critical Design Review (CDR) at end of Phase I. The Phase I products are the CDR materials, the final report, and a Phase II proposal (if requested).

Phase II: In Phase II, the contractor will finalize their design and build a prototype solid state laser device. Sufficient testing and diagnostics will be carried out to assess aspects such as pulse energy, temporal stability, beam quality, electrical efficiency, thermal management, and turn-on times. The Phase II device will certainly not be fully space qualified. However, it should not employ integral parts, materials, or subsystems that clearly preclude eventual space-qualification of the underlying laser technology. The products from Phase II should include the laser device, the performance test data, and the final report.

Dual Use Commercialization Potential: The demand on all aspects of laser performance in prolonged space operation is so great that once 100-W class 1-micron lasers suitable for space applications are developed, the new technologies could be applied in a variety of tactical laser systems for land, air, ship as well as satellite based platforms. Compact 1-micron lasers may also find commercial applicability in manufacturing, chemical sensing, medical, and a variety of other industries. A Phase III program might also involve further cooperative work toward full space qualification of the laser technology developed under the Phase II program.

Related References:
1. Proceedings of the Advanced Solid State Lasers Conference, 2001 and references therein.
2. Afzal, R. S., Mars Observer Laser Altimeter: Laser Transmitter, Appl. Opt., vol. 33, p. 3184, (94).

3. El-Dinary, A. S., et. al., Testing and Space Qualification of the NEAR Laser Rangefinder, Proc. SPIE., vol. 2748, p. 140, (96).

KEYWORDS: Lasers, Solid State Lasers, Diode Lasers, Non Linear Optics, Nd-YAG, Space Qualification, Laser Communication, Remote Sensing, Chemical, Biological, Imaging, Tracking

AF03-005 TITLE: Active Optical Remote Sensing System for Ground Contamination Detection

TECHNOLOGY AREAS: Chemical/Bio Defense, Sensors, Electronics, Battlespace

Objective: Develop and demonstrate an active optical surface chemical contamination detection technique that can be applied to an airborne capability.

Description: The ability to detect ground contamination is a critical requirement to perform bomb damage assessment, detect and identify chemical weapons and military production facilities, ensure the safety of military personnel being inserted into an area, or to guide ground troop movements. The technology sought is an active optical system that transmits energy to the target area, and uses the return energy to detect and identify ground contamination. Possible detection mechanisms may include, but should not be limited to, differential scattering (DISC), Raman spectroscopy, etc. The system needs to detect multiple hazardous agents, operate in the presence of interfering chemicals, and perform accurately for differing ground surface compositions (e.g., rocky terrain, grass, soil, concrete, etc.). The required detection capability is envisioned for eventual use on both rotary- and fixed-wing aircraft, with one-way standoff ranges of approximately 1 to 5 kilometers.

Phase I: Define the proposed concept, system requirements, and detection mechanism. Develop key component technological milestones and preliminary design of system or components that address the above desired capabilities. The system approach is desired in order to ensure that the components developed have utility in meeting the requirements defined above and can be suitably field-tested with existing government furnished equipment or hardware (GFE) in Phase II.

Phase II: Complete component design, fabrication, and laboratory characterization experiments. Define field test objectives and conduct limited testing with available GFE, if needed. Airborne demonstration is desirable but not required. Airborne requirements should be considered and included in the system design.

Dual Use Commercialization Potential: The proposed system would find commercial utility in pollution monitoring and environmental cleanup applications, with little required modification. Military applications include detecting surface contamination from chemical weapons and toxic materials.

Related References:
1. Senft, D.C., M.J. Fox, C.M. Hamilton, D.A. Richter, N.S. Higdon, B.T. Kelly, R.D. Babnick, and D.F. Pierrottet, “Chemical detection results from ground testing of an airborne CO2 differential absorption lidar system,” Air Monitoring and Detection of Chemical and Biological Agents II, SPIE Vol. 3855, 144-156, 1999.
2. Senft, D.C., M.J. Fox, C.M. Hamilton, D.A. Richter, N.S. Higdon, and B.T. Kelly, "Performance Characterization and Ground Testing of an Airborne CO2 Differential Absorption Lidar System (Phase II)," Laser Radar Technology and Applications IV, SPIE Vol. 3707, 165-176, 1999.

KEYWORDS: Lidar, Chemical Sensing, Ground Contamination Detection, Stand-off Detection, Differential Absorption Lidar (DIAL), Differential Scattering (DISC), Raman Spectroscopy

AF03-006 TITLE: High-Energy Laser Coatings for Large, Lightweight, and Compliant Deployable Space Optics

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

Objective: Develop a cost-effective method to apply High-Energy Laser (HEL) coatings to compliant polyamide materials for high-priority Air Force applications.

Description: The Air Force's current thrust is to develop methods of applying HEL (>1MW) coatings to optics for use in a range of applications that would require high-power systems. These applications include a much larger optic than in the past and one train of thought is to use compliant polyamide materials with a specific reflective coating to serve the needs of the using system. There are many challenges to solve to incorporated this technology to compliant substrate.

· One of the first challenges is the adhesion of the coating to the polyamide material. It is critical to understand the importance of how to maintain the bond between the coating and the membrane, so to avoid delamination or cracking of the coating when the membrane is activated, such as through packaging.
·The next technology that needs to be developed is to figure out how many layers are needed to reflect 99.99% of the energy projected onto the surface of the membrane. This is a start to the requirements of the current thrusts of the DoD and other government agencies. At this same time, it is important to recognize the need for optical tolerances in the coating.
·In the past the energy that is not reflected has been transmitted into the solid optic. Preliminary studies show obvious differences in what will happen with these ultra-thin compliant polyamide materials. Some empirical data needs to be taken to verify these studies. The question here is where does the energy that is not reflected go (i.e. is it transmitted through the file or spread through the film, etc.).
·Another aspect along these same lines is the physical effects the High-Energy Laser would have on the coated polyamide material. Such effects might include, but not limited to, induction of vibrations, photon pressure and possible heating of the substrate. A study should be conducted to look at these and other effects that might reduce performance time.
·It would be optimal if the coating could also be dual use. The secondary use for these coatings would be to use the residual stress in the coating as a structural support for the compliant membranes. These membranes are cast in a parabolic shape, but tend to shrink when removed from the cast. These coatings can be used to balance the membrane's shrinkage force with the coating's expansion forces.
·Eventually, the membranes that will be used will be larger than 10 meters, scaling must be addressed. An initial study of how the deposition process could be scaled should be looked into in phase I. Such areas to look at is the vacuum chamber, the type of deposition process, and the different types of coatings to use. These are just a few examples of the areas that need to be researched for the membrane-coating interface.

This SBIR is searching for fundamental technologies that will lead to the application of HEL coatings to large compliant substrates for many commercial and government applications.

Phase I: The contractor shall model their selected approach to show the adhesion capabilities of the coating. It is important to look at the reflectivity and transmitted rates. Coupon or small scale material testing will be used to prove the technology can be used with compliant substrates. Dual-use applicability for the coating should be addressed. Scalability and applicability of the concept to the space environment must be addressed.

Phase II: The contractor shall use the results of Phase I to build, test, and refine a multi-meter test article. They shall also continue to further the development of some of the above technologies.

Dual Use Commercialization Potential: These coatings have many general uses, including, but not limited to the following: Relay Mirror, Space-Based Laser, Large Aperture Space-Based Telescopes.

Related References:
1. M. T. Gruneisen and J. M. Wilkes, "Compensated imaging by real-time holography with optically addressed spatial light modulators," in Spatial Light Modulators, G. Burdge and S. C. Esener, eds., OSA TOPS 14, pp. 220-226, 1997.

2. M. T. Gruneisen, D. V. Wick, T. Martinez, and J. M. Wilkes, "Correction of large dynamic aberrations by real-time holography using electro-optical evices and nonlinear optical media," in Artificial Turbulence for Imaging and Wave Propagation, J. D. Gonglewski and M. A. Vorontsov, eds., Proceedings of SPIE 3432, pp. 137-150, 1998.
3. D. K. Marker and C. H. Jenkins, "Surface precision of optical membranes with curvature," Optics Express 1, pp. 324-331, 1997. Published online at www.osa.org.
4. J. M. Wilkes, "Applications of power series solutions of membrane equilibrium equations to the optical evaluation of membrane mirrors with urvature," Tech. Report AFRL-DE-PS-TR-1998-1069, Air Force Research Laboratory, December 1998.
5. J. M. Wilkes, C. H. Jenkins, D. K. Marker, R. A. Carreras, D. C. Duneman, and J. R. Rotge, "Concave membrane mirrors from aspheric to near-arabolic," in High-Resolution Wavefront Control: Methods, Devices, and Applications, J. D. Gonglewski and M. A. Vorontsov, eds., Proceedings of SPIE 3760, pp. 213-223, 1999.

KEYWORDS: Membrane Optics, Optical Quality Reflectors, Thin Films, Reflectors, Large Aperture, Compliant Substrates, High Energy Laser, Coatings

AF03-007 TITLE: High Power Short Pulse Transmit/Receive Isolation Device

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: Develop a device that will isolate/protect a mono-static receiver antenna from a high power short pulse radiated signal.

Description: This effort is to develop a high power isolation device that will allow a single antenna to be used for both transmit and receive modes in an wideband (WB) target identification system. This device must be capable of isolating sensitive receiver front-end components during the high power transmit mode of the pulser. The source levels range from 100 to 500 kilovolts with rise-times on the order of 100 to 250 picoseconds with a pulse duration of 4 to 6 nanoseconds. Repetition rates may range from 200 Hz to 5 kHz. The insertion loss during the receive mode must be kept to a minimum. The approaches to develop the isolation device may include solid-state switches, directional couplers, high impedance/limiter circuits, plasma-shielded sensors, or any combination of these or other technologies.

Phase I: Investigate different approaches and concepts for designing a high power, fast switching and low leakage isolation switch. Perform analysis, modeling, and/or experiments to demonstrate key/critical features of the design approaches considered as potentially feasible. Develop an initial commercialization concept and plan.

Phase II: Complete the investigations begun in Phase I and down select those approaches that appear to be most feasible for further research and experiments. Based on the results of the detailed analysis, design and build a prototype switch or switches. The switching characteristics for single and repetition rates up to 5000 pulses per second, leakage currents, and other performance parameters shall be characterized and documented. Develop a business and commercialization plan for a Phase III engineering development and marketing program. This plan shall be required to address the real world issues associated based on actual business planning procedures, sources and methods of securing venture capital for production engineering and marketing, and not just a superficial discussion of possible approaches and possible customers.

Dual Use Commercialization Potential: Military uses of this technology include HPM weapon research and development and target identification. Civilian sector applications include research and development of pulse position communications systems and for the development of fast ground penetrating radar for locating and identifying buried pipes, abandoned fuel storage tanks, and hazardous debris.

Related References:
1. Carl E. Baum, “A Sensor for Voltage, Current, and Waves in Coaxial Cables,” Sensor and Simulation Note 447, 20 April 2000, Air Force Research Laboratory, Directed Energy Directorate/High Power Microwave Division, 3550 Aberdeen Ave. SE, Kirtland AFB, NM 87117-5776.

2. Marc Piette, “Ultra-Wideband Duplexers for Low and High Peak Power Applications,” Ultra-Wideband Short-Pulse Electromagnetics 4, 1999, Kluwer Academic/Plenum Publishers, 233 Spring Street, New York, NY, 10013, pages 187-193, ISBN 0-306-46206-0.
3. William D. Prather, et al., “Ultra-Wideband Sources and Antennas,” Ultra-Wideband Short-Pulse Electromagnetics 4, 1999, Kluwer Academic/Plenum Publishers, 233 Spring Street, New York, NY, 10013, pages 119-130, ISBN 0-306-46206-0.

KEYWORDS: Antennas, Mono-static, Transmit, Receive, Electromagnetics, Transient

AF03-008 TITLE: Pulsed Solid State Laser Illuminators for Tactical Air Platforms

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms, Weapons

Objective: Develop compact, rugged, portable, and efficient 1-micron, solid state lasers for Air Force applications.

Description: A wide range of technology areas of interest to the Air Force call for powerful, high quality laser sources to remotely illuminate objects. Precision tracking of airborne missiles, atmospheric sensing, and active imaging are some of the applications requiring state-of-the-art laser systems. Although major strides have been made over the past few decades, the utility of commercially available solid state lasers (SSLs) for military missions still lags behind the vision of system developers. However, the steady improvements in laser technology are now starting to point toward fairly near-term realizations of advanced photonic systems that have the potential to revolutionize national defense. Illuminator class lasers will play an important role in many of these new systems. Beyond meeting the desired power and beam quality specifications, these lasers must satisfy weight, volume, cooling, efficiency, and logistics requirements that are compatible with integration and operation on a wide variety of platforms. This SBIR topic seeks to push toward this goal by seeding development in the specific area of one-micron, pulsed (2-10kHz), diffraction limited, linearly polarized, SSL illuminators at the 100-250W average power level. Certainly, lasers at these power levels have been built in the past, but in most cases, particular aspects of the designs preclude the ready integration into operational systems intended for the most demanding applications.

Phase I: The Phase I objective will be to use appropriate design tools, experimentation, research, and analysis to develop a rugged design for a pulsed solid state laser device to be built and tested in Phase II. The mechanical design, along with the power control and cooling systems, should employ state-of-the-art components and methods that address issues of compactness, ruggedness, efficiency, reliability, etc. The output wavelength should fall within the 0.8-2 micron band. A near diffraction limited (M-squared<1.3) output beam is required. The laser should operate continuously (100% duty cycle) with industrial chillers, but also be adaptable to lower duty cycle, reduced heat load operation using more compact, portable cooling systems. The program goal is a nominal 250W average power Q-switched laser output beam with a selectable repetition rate between 2 and 10 kHz. Material issues may limit the average power at the lower repetition rates, so a goal of >100W at 2 kHz is specified. Compelling designs at somewhat lower power levels or reduced duty cycles may also be considered for funding. Linearly polarized output beams are preferred. Shorter coherence length (< few cm) pulses are preferred over those approaching the transform limit. The proposed system design must be realizable within the scope of a Phase II SBIR contract. Risk reduction tasks that support the design may be carried out in Phase I. The Phase I products are the laser design, the final report, and a Phase II proposal (if requested).

Phase II: In Phase II, the contractor will build a prototype SSL device based on their Phase I design. The contractor will also perform measurements on the device to assess its performance against the program goals and to evaluate how the underlying design might be suitable for tactical illuminator. These might include, but are not limited to, pulse energy, jitter (temporal and spatial), wall-plug efficiency, system weight, beam quality, and turn-on time. The Phase II device should be packaged well enough to be moved, set up, and operated by a trained technician. The products from Phase II should include the laser device with the power supplies and chillers, the performance test data, and the final report.

Dual Use Commercialization Potential: A well–designed laser device of the type described in this topic will exceed the state-of-the-art in commercially available systems. Affordable, compact, powerful one-micron lasers could capture market share in materials processing, manufacturing, and a variety of other industries. Frequency conversion could further expand the commercialization opportunities. A Phase III program might also involve government related work on further hardening and/or integration of the Phase II laser technology.

Related References:
1. Sumida, D. S. and Fan, T. Y., Room temperature 50mJ/pulse side-diode-pumped Yb:YAG laser, Opt. Lett. vol. 20, p. 2384 (1995).
2. Goodno, G. D., et. al., Yb:YAG power oscillator with high brightness and linear polarization, Opt. Lett. vol. 26, p. 1672 (2001).
3. Riesbeck, T., Risse E, and Eichler H. J., Pulsed solid state laser system with fiber phase conjugation and 315 W average output power, Appl. Phys. B, vol. 73, p. 847 (2001).
4. Magni, V., et. al., Rod imaging supergaussian unstable resonator for high power solid state lasers, Opt. Comm., vol. 94, p. 87, (1992).
5. Giesen, A.,et. al., Scalable concept for diode pumped high power solid state lasers, Appl. Phys. B, vol. 58, p. 365, (1994).

KEYWORDS: Solid State Laser, Nd:YAG, Yb:YAG, High Brightness Laser, One Micron Laser, Q-switched Laser, Diode Pumped, Laser Thermal Management, Phase Conjugation

AF03-009 TITLE: Spatially Modulated Reflective Membranes for High-Dynamic-Range Wavefront Control

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: Develop spatially modulated reflective membranes for high-dynamic-range wavefront control.

Description: Comprehensive laser wavefront control requires the ability to transfer onto a laser beam all of the features described in a general two-dimensional polynomial representation. This includes conventional beam control functions such as tip, tilt and focus as well as adaptive optics functions for aberration compensation and general wavefront shaping. Conventional deformable mirrors operating with independent two-dimensional addressing are currently utilized for such multi-function wavefront control, but with a dynamic range that is limited to a few microns of optical path difference (OPD)[1]. Applications involving severe aberration compensation require significantly larger dynamic ranges that exceed this by one to two orders of magnitude. Recent demonstrations performed with liquid-crystal phase modulators [2,3] have shown the feasibility of utilizing thin modulo-lambda diffraction gratings to achieve high optical efficiency, high-dynamic-range (100s of optical wavelengths) wavefront control with low dynamic range (one optical wavelength of modulation) devices. While potentially useful for some applications, liquid-crystal-based devices introduce some limitations due to absorption and scattering in the LC media and transparent electrodes as well as polarization-dependent phase modulation and relatively low temporal bandwidth. These issues make problematic the extension of this technology to infrared wavelengths, modest optical power, and high-speed operation. Also, the diffractive technique, while useful for monochromatic applications, operates with limited spectral bandwidth due to the angular dispersion associated with diffraction.

In principle, many of these limitations can be overcome with a technology based on thin reflective membranes [4,5]. A reflective surface avoids many of the problems inherent to transmissive media. Furthermore, a thin membrane may avoid limitations in displacement and spatial resolution associated with thick substrates. This SBIR solicits novel approaches to high-dynamic-range wavefront control based on high-resolution spatially modulated reflective membranes. Two approaches are envisioned;

Approach 1. Develop large-throw reflective modulators, useful for broad spectral bandwidth applications, with about 50 wavelengths of surface displacement at the operating wavelength. This corresponds to 100 wavelengths in reflection.

Approach 2: Develop small-throw reflective modulators with one-half wavelength of displacement at the operating wavelength. This corresponds to one wavelength in reflection.

Furthermore, to be useful for DOD and commercial applications, speed, resolution, aperture size, optical quality, optical power capability and spectral characteristics are required as described below.

Resolution: Implementation of this technique requires that the wavefront control device adequately resolve each 2pi increment of phase modulation. Thus, assuming about 10 resolution elements per 2pi increment and 100 waves of two-dimensional OPD, we would require a device with about 1000 by 1000 independently addressable elements. Thus, the technology must be consistent with scaling to megapixel class devices.

Addressing Schemes: Architectures for addressing the wavefront control device may include electrostatic, mechanical, micromechanical and optical actuation. An important goal of the work will be to develop addressing architectures that are consistent with the rapid addressing of up to one million elements. The system should interface to standard desktop computers.

Speed: While the required operating speed will depend on the specific application, 1 kHz is considered to be an operating speed that would make this technology broadly applicable.

Optical Efficiency: The total optical efficiency of the device will be the product of the realizable diffraction efficiency (for approach 2) and the optical throughput associated with fill factor and reflectivity. Compatibility with high-reflectivity coatings is important, not only for minimizing optical losses, but also to avoid damage at high optical power. Total optical efficiencies in excess of 95% are desirable.

Aperture Size: One important application is large aperture optical systems. Systems of interest require wavefront control devices ranging from 10 to 100 cm diameter.

Operating Wavelength: Wavelength regions of interest include the visible spectrum 400 to 700 nm, the 1 to 2 micron band, the 3 to 5 micron band, and the 8 to 12 micron band. While diffractive techniques are inherently wavelength sensitive due to angular dispersion, it is desirable that a single device is capable of being tuned within a given band and even capable of being tuned to multiple bands. At each operating wavelength, the dynamic range must be one wavelength in reflection.

Optical Quality: Small-scale optical quality must be sufficient to minimize light loss due to scattering. Coarse scale optical quality should be better than two wavelengths at the operating wavelength. This tolerance is relaxed from the conventional standard, lambda/10, since it is acceptable to use a small portion of the wavefront control dynamic range to compensate for non-flatness. However, the device (excluding the membrane) should be mechanically rigid so the surface shape is not changing in time due to mechanical instabilities.

This SBIR is searching for fundamental technologies that will advance the technical performance and commercialization of high-dynamic-range laser wavefront control.

Phase I: The contractor shall design and demonstrate component architectures that are consistent with the technical goals articulated above. These include demonstrating solutions to:
1. Addressing very large numbers of elements,
2. Achieving independent element addressing with minimal inter-element cross talk, and
3. Demonstrating solutions to the issue of scaling the technology to 1-meter diameter apertures.

Phase II: The contractor shall use the results of Phase I to build, test, and refine a 10 to 100 cm aperture, one megapixel high-dynamic-range wavefront control device.

Dual Use Commercialization Potential: This technology has the potential to be an enabling technology for many applications, including, but not limited to the following: Severe aberration compensation in imaging and beam-directing optical systems, phasing of optical fiber arrays, laser cavity mode control, programmable laser machining, retinal imaging, robotic surgery, optical tweezers for bioengineering and 3-D holographic displays.

Related References:
1. See for example, Xinetics web site, www.tiac.net/users/xinetics.

2. P. F. McManamon, T. A. Dorschner, D. L. Corkum, L. J. Friedman, D. S. Hobbs, M. Holz, S. Liberman, H. Q. Nguyen, D. P. Resler, R. C. Sharp, and E. A. Watson, "Optical Phased Array Technology," Proceedings of the IEEE, Vol. 84, No. 2, 268-298 (1996).
3. M. T. Gruneisen, T. Martinez and D. L. Lubin, "Dynamic Holography for High-Dynamic-Range Two-Dimensional Laser Wavefront Control," in High-Resolution Wavefront Control: Methods, Devices, and Applications, John D. Gonglewski, Mikhail A. Vorontsov, and Mark T. Gruneisen, Editors, Proceedings of SPIE, 224-238 (2001).
4. J. D. Mansell, S. Sinha, R. L. Byer, "Adaptive Optics Development for Laser Systems," Proceedings of SPIE, vol. 4493 (2001).
5. C. Warde and J. E. Hubbard, Jr., "Membrane-Mirror-Light-Valve-Based Infrared Scene Projector," Proceedings of SPIE, vol. 2223, 544-557 (1994).

KEYWORDS: High Dynamic Range Wavefront Control, Holographic Recording Materials, Aberration Compensation, Spatial Light Modulators, Adaptive Optics, Membrane Optics.

AF03-010 TITLE: Narrow Band High Power Antennas for Airborne Platforms

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

Objective: Develop high power narrowband antennas that can be integrated into existing airborne platforms.

Description: This effort will develop concepts, design, and build a prototype narrow band (NB) antenna capable of being integrated into an airborne platform. The extremely high power generated by High Power Microwave (HPM) sources tends to cause air breakdown when radiated from antennas small enough to be mounted on airborne platforms. Larger antennas can be used to reduce the field levels sufficiently to eliminate the air breakdown, but large size is undesirable and often difficult to integrate into the aerodynamic design of a platform. Other approaches have investigated the use of bags filled with sulfur hexafluoride gas to prevent breakdown in the immediate area of the antenna, but they have integration problems as well. What is needed is a narrow band antenna nominally operating around 1.0 GHz with input power levels up to 1 GW that can be integrated into an airborne platform without causing air breakdown. It is anticipated such an antenna will not be a “plug and play” payload component in most current airborne systems or concepts. The antenna concept will most likely have to be an integral design of an airborne platform rather that a payload on current designs. However, if a design concept can be developed and demonstrated that can be easily adapted to existing airborne platforms, it will be given priority over other concepts. The antenna’s other properties: weight, size, and structural integrity must be consistent with an airborne application. The antenna beam pattern should be highly directional, have minimum side and back lobes, and be high gain.

Phase I: Investigate antenna concepts and perform analytical and numerical analyses to determine feasibility, establish initial design parameters, and estimated performance characteristics. Evaluate and document initial estimates of the physical design characteristics, airframe integration issues, power requirements, antenna patterns, and other factors such as air breakdown and antenna/structure interactions. Develop an initial commercialization concept and plan.

Phase II: Complete the investigations begun in Phase I and down select those approaches that appear to be most feasible for further research and experiments. Based on the results of the detailed studies, design and build a conceptual prototype system. This conceptual system shall include the antenna system integrated into a mockup of an airframe. The airframe mockup does not have to be engineered for actual flight and may be a sub scale model of an actual system. The scaling shall be compatible with the frequencies and airframe details required feasibility demonstration of the approach. Conduct experiments and measurements of the conceptual prototype system to characterize the antenna performance and patterns. Develop a business and commercialization plan for a Phase III engineering development and marketing program. This plan shall be required to address the real world issues associated introducing a new product into the market based on actual business planning procedures, sources and methods of securing venture capital for production engineering and marketing, and not just a superficial discussion of possible approaches and possible customers.

Dual Use Commercialization Potential: Military uses of this technology include airborne HPM weapon applications. Civilian sector applications include mobile or airborne microwave communications systems.

Related References:

1. C.D. Taylor and D.V. Giri, High-Power Microwave Systems and Effects, Taylor & Francis, Washington, DC, 1994.
2. Applications of High-Power Microwaves, A.V. Gaponov-Grekhov and V.L. Granatstein, Eds., Artech House, Boston, 1994.
3. High-Power Microwave Sources, V.L. Granatstein and I. Alexeff, Eds., Artech House, Boston, 1987.
4. J. Benford and J. Swegle, High-Power Microwaves, Artech House, Boston, 1992.
5. R.C. Johnson, Designer Notes for Microwave Antennas, Artech House, Boston, 1991.

KEYWORDS: Microwaves, High Power, Airborne, Aerodynamic, Air Breakdown, antennas

AF03-011 TITLE: <u>High Power Mid-Infrared (2-10 Micron) Diode Laser Development</u>

TECHNOLOGY AREAS: Sensors, Weapons

Objective: Develop the next generation of high power two to ten micron semiconductor laser diodes and laser diode arrays.

Description: High power mid-IR diode arrays have recently been demonstrated and play a key role as pump sources for longer-wavelength optically pumped lasers (e.g.- 4 micron lasers). However, since the primary interest of the commercial diode industry is in telecommunication lasers, which operate in the near-IR (below 1 micron), there are no commercial vendors for high power mid-IR laser diodes or laser diode arrays. In fact, companies that recently were able to provide high power 2 um arrays no longer do so and consequently, the next generation of these important class of diode lasers is not being developed. Further, Lucent technologies, which pioneered the quantum cascade laser, does not sell these mid-IR lasers commercially. The aim of this SBIR effort will be to encourage the development and manufacture of the next generation of high power laser diodes and laser diode arrays that emit in the 2 to 10 micron region. There are many important applications for intense, coherent, mid-infrared, diode laser sources including infrared countermeasures, secure communications, infrared imaging, target designation and trace gas sensing. Toxic gas sensing is a particular important application as it relates to homeland defense. There are many toxic gases that have strong absorption lines in the 2-10 micron region, such as hydrogen cyanide at 3 um. Further, mid-IR diodes are also ideally suited as sources for short range (< 1 km) chemical warfare trace gas monitoring in the LIDAR mode. A major military application is infrared-countermeasures (IRCM). In recent military conflicts, about 85% of the air-combat losses were from surface to air missiles. The effectiveness of SAMS, coupled with their low cost, indicates the necessity of equally effective IRCM systems. Certainly, IRCM systems based on mid-IR diode arrays are top candidates to fill this role.

Phase I: At the end of phase one, epitaxial materials will be specified as well as high power diode architectures. An initial wafer growth and testing of a mid-IR diode or diode bar will be required.

Phase II: Grow and optimize 2-10 micron materials for inclusion in high-power 2-10 um linear diode arrays and other high power architectures. Several prototype laser diode arrays and/or diodes will be delivered at the end of phase-II.

Dual Use Commercialization Potential: High power mid-IR diode lasers have several military and civilian applications. The military applications include infrared countermeasures (IRCM), illumination, targeting, collision avoidance, IFF, secure communication, and WMD detection. The civilian applications include optical pumps for mid-IR lasers, sources for long-baseline remote sensing, and medical applications.

Related References:

1. F. Capasso, C. Gmachl, A. Tredicucci, A. Hutchinson, D. Sivco, and A. Cho, “High Performance Quantum Cascade Lasers”, Optics and Photonics News, October 1999, 32-37.

2. C. Felix, et. al. "Near room-temperature midinfrared interband cascade laser", Appl. Phys. Lett., 74(4), 628, 1999.
3. R.Kaspi, et. al., "Optically pumped integrated absorber 3.4 micron laser with InAs-to-InGaAsSb type-II transition", Appl. Phys. Lett., 79(3), 302, 2001.
4. B. Lane, et. al., "High Power InAsSb/InAsSbP electrical injection laser diodes emitting between 3 and 5 microns", Materials Sci. and Engin. B-Solid State Materials for Advanced Technology, 74(1-3), 52, 2000.

KEYWORDS: Semiconductor Laser, Gallium Antimonide, Quantum Cascade Laser, Remote Sensing, Interband Cascade Laser, IRCM

AF03-015 TITLE: Innovative Measurement Techniques for Space-Based Remote Sensing/Standoff Detection

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Electronic Systems Center (ESC)

Objective: Develop innovative measurement techniques for space-based remote sensing / standoff detection.

Description: The Air Force Research Laboratory is interested in innovative techniques and approaches that leverage recent progress in commercial technology to characterize the optical properties of the environment, to optimize object detection, search, and track capabilities in structured environments, to identify materials, and to identify and quantify atmospheric constituents/effluents. Examples include passive optical techniques that collect spectral, spatial and temporal data. Many commercial technologies are emerging that could be developed into innovative measurement technologies. The focus of the efforts will be directed toward space-based applications.

Phase I: Conduct analyses which compare candidate data-collection and analysis approaches to current technologies with respect to sensitivity, spectral and/or spatial resolution, temporal resolution, et cetera. New data-collection and data-processing methodologies will be defined and assessed in terms of object-to-background contrast enhancement and/or clutter suppression, as well as for accuracy and speed. Exploration of techniques to identify materials and to identify and quantify atmospheric constituents/effluents will also be examined. The effort should include an investigation of ways in which new technologies could be applied to other military and commercial applications.

Phase II: Conduct tests to determine how effectively the proposed techniques address the requirements of the intended applications). In Phase II an automated, near-real-time, data-processing system will be developed and demonstrated using synthetic and real data.

Dual Use Commercialization Potential: The techniques and methodologies developed under this effort will potentially be useful in Phase III in military systems requiring autonomous threat recognition and identification under stressing conditions of cloud and haze cover, sensor clutter induced by scene structure, as well as for the identification of materials, and to identify and quantify atmospheric constituents/effluents. It will potentially also be useful for non-military applications involving target/species recognition under stressing real-world conditions of scene-induced clutter/noise and spectral interference.

Related References:
1. Atmospheric correction of hyperspectral data in terms of the determination of plant parameters, H. Bake and W. Mauser in "Recent advances in remote sensing and hyperspectral remote sensing"; Proceedings of the SPIE Conference, Rome, Italy, Sept. 27-29, 1994, Vol. 2318, 1994, pages 52-62.
2. "Infrared spaceborne remote sensing III", Proceedings of the SPIE Meeting, San Diego, CA, July 12-14, 1995, M. S. Scholl and B. F. Andresen, eds.
3. Target detection in desert backgrounds - Infrared hyperspectral measurements and analysis, M. T. Eismann et al., in "Signal and data processing of small targets", Proceedings of the SPIE Meeting, San Diego, CA, July 11-13, 1995, Vol. 2561, 1995, pages 80-97.
4. Use of hyperspectral imagery for broad-area detection of small targets, W.F. Kailey in "Imaging spectrometry II", Proceedings of the SPIE Meeting, Denver, CO, 7-8 Aug 1996, Vol. 2819, 1996, pages 15-23.

5. Application of hyperspectral imaging spectrometer systems to industrial inspection, C.T.Willoughby et al. in "Three-dimensional and unconventional imaging for industrial inspection and metrology; Proceedings of the SPIE Meeting, Philadelphia, PA, Oct. 23-25, 1995, Vol. 2599, 1996, pages 264-272.

KEYWORDS: Multispectral, Hyperspectral, Ultraspectral, Ultraviolet, Visible, Infrared, Remote Sensing, Spectral Signatures, Target Detection

AF03-016 TITLE: Long-term Ionospheric Forecasting System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space and Missile Systems Center (SMC)

Objective: Design, build, and test a forecast system capable of providing improved long-term (out to three days) ionospheric forecasting.

Description: The near-earth space environment has a direct and sometimes deleterious effect on military operations. Systematic variations and erturbations in the ionospheric density can adversely affect communications, spacecraft charging, Global Positioning System (GPS) navigation, radar surveillance, and geolocation. Changes in neutral density modify the orbits of satellites and degrade our ability to predict their position and reentry. Military and civilian operations, both terrestrial and near-space, therefore rely on accurate models of the ionosphere and thermosphere. Ionospheric forecasting capabilities are steadily improving, particularly as a result of the use of data-assimilation techniques which permit the increasing amount of ionospheric data (e.g., TEC measurements) to help specify the current state of the ionosphere. The accuracy of forecasts based on ionospheric data alone, however, noticeably degrades after an interval of a few hours. The variability and unpredictability of the ionosphere is due in large part to the fact that it is strongly influenced by the driving forces of external factors, particularly the solar wind and solar energetic-photon flux, which are themselves the result of complicated, unpredictable dynamics within the Sun. These solar phenomena are observable, however (e.g. UV and EUV emissions, flares, coronal mass ejections), and we expect that, by assimilating knowledge of these events and other information into an ionospheric forecast system, we can improve its long-term forecast accuracy. Thus, the objective of this SBIR effort is to develop an innovative capability to provide improved long-term forecasts of the ionosphere. The forecast should cover the approximate period from 6 to 72 hours. The ionospheric forecast model could be developed to forecast the plasma and neutral densities, the plasma drifts and neutral winds, and temperatures within the ionosphere. Because the accuracy of space weather products relies on the use of validated models for ionospheric forecasting, a documented validation process for the model will be an important component of the SBIR effort.

Phase I: Undertake a concept study to determine the feasibility of developing a global ionospheric forecast system. This concept study shall include a functional description of a forecast system capable of providing up to 3-day forecasts of global ionospheric densities within the altitude range 100 km to 1000 km. The concept study shall include realistic quantitative goals for determining environmental parameters such as the electron density profile and the identification of standard ionospheric features. Risks or limitations associated with the development of the ionospheric forecast system should be discussed.

Phase II: Develop a prototype global ionospheric forecast system. The forecast system should be computationally based and should use, as input parameters, readily available space environmental data parameters. The prototype system shall provide a 6-hour (threshold) to 3-day (objective) forecast of global ionospheric densities, including the electron density profile and identification of standard Chapman features. The performance of the forecast system shall be verified and validated using relevant ionospheric data and metrics.

Dual Use Commercialization Potential: The ionospheric forecast system developed under this program will have significant dual-use potential. Space weather affects numerous technologies, including high-frequency radio communications, radar, and GPS navigation systems. Industries affected include telecommunications, aviation, satellite manufacturers, electric-power distribution systems, and all users of GPS. The development of the ionospheric forecast system is consistent with the goal of the National Space Weather Program to advance space weather forecasting accuracy and reliability. Also, as noted in the National Security Space Architect Space Weather

Architecture Study there is a need for the commercial sector to develop space weather forecasts tailored to specific applications. The ionospheric forecast system developed under this SBIR will be greatly beneficial to industry.

Related References: Wright, J. M., The National Space Weather Program – The Strategic Plan, 1995 (http://www.geo.nsf.gov/atm/nswp/nswp.htm).

KEYWORDS: Space Weather, Space Environmental Effects, HF communications, Neutral Density, Ionospheric Density, Satellite Drag

AF03-018 TITLE: Small Vehicle Launch Technology

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop innovative Small Launch Vehicle (SLV) technologies that provide responsive, cost effective Spacelift solutions for Small-Sat architectures.

Description: As satellite micro-miniaturization technologies show increasing promise in improved mission capability at significantly reduced spacecraft weight and cost, a complementary need will undoubtedly exist for a responsive, cost effective SLV. Innovative technologies are being sought that address SLV responsiveness and cost reduction in the areas of avionics, propulsion, airframe and structures, manufacturing, integration, and/or operations. A vehicle focus identifies enabling SLV technologies using a SBIR time-phased, risk reduction approach. Development of these technologies will make possible the eventual acquisition and operation of a responsive and cost effective SLV-based system capable of rapidly deploying small satellites (under 1000lbs.) to low earth orbit (LEO).

Phase I: Conduct necessary feasibility and conceptual studies to develop a sub-orbital vehicle conceptual design and supporting technology requirements base, traceable to an orbit capable SLV, whereby specific technologies are identified for Phase II development/test. Specifically, proposed Phase II SLV technology demonstrations must address a unique combination of improved launch responsiveness and cost reduction technologies. This will require technology risk mitigation plans that addresses identification, rationale, and test exit criteria of proposed high-risk component(s) in meeting advertised improvements to SLV launch responsiveness and cost.

Phase II: Refine the conceptual design of the sub-orbital vehicle and carry on the research and development of the identified key technologies up through the prototype phase. The prototype hardware shall emphasize launch responsiveness and cost reduction technologies, possessing sufficient design information to fabricate, integrate, and operate the selected high-risk component(s) for demonstration. The contractor shall perform prototype ground test and evaluation of the enabling component (s) per the Phase I technology risk mitigation plan. Phase II shall demonstrate critical component technologies that address launch responsiveness and/or cost reduction, which sufficiently meet required subsystem performance and reliability requirements. The government will evaluate this information to determine whether a follow-on Air Force funded Phase III sub-orbital flight program is warranted.

Dual Use Commercialization Potential: Dual use applications include target vehicles, sounding rockets, Ballistic Missile Replacement (BMR) and strap-on boosters. Enabling technologies that evolve from this program are directly traceable to a new responsive and low cost SLV for both commercial and military applications. A responsive SLV would enhance the launching of military tactical satellites for theater Intelligence, Surveillance and Reconnaissance (ISR). A low cost SLV would enhance the deployment of commercial LEO Communications Constellations (e.g., Store and forward paging communication systems). Other dual use variants of this technology include booster and/or upper stages systems for larger launch vehicles. If Phase II technical exit criteria are met and commercial and/or government (non-SBIR) program funds are identified for Phase III, the contractor shall design, fabricate, integrate, and flight-test the sub-orbital vehicle as defined under Phases I-II.

Related References:
1. Steven J. Isakowitz, "International Reference To Space Launch Systems," AIAA, Second Edition, 1991.

2. George P. Sutton, Rocket Propulsion Elements, John Wiley & Sons, Sixth Edition, 1992.3. James R. Wertz and Wiley J. Larson (editors), "Reducing Space Mission Cost," Microcosm/Kluwer, 1996.

KEYWORDS: Launch Vehicle Design, Sub-Orbital Vehicle, Satellite Micro-miniaturization, Technology Risk Mitigation, Flight Test

AF03-019 TITLE: Common Aero Vehicle Payload and Avionics Isolation

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Identify a candidate material to protect the Common Aero Vehicle (CAV) payloads and avionics from thermal, acoustic, vibration, and shock environments.

Description: The Common Aero Vehicle is a maneuvering re-entry vehicle designed to deliver payloads such as air-to-ground weapons from space through the atmosphere to an impact point or submunition release point. The CAV would be placed in space using either Expendable Launch Vehicles (ELVs) or Reusable Launch Vehicles (RLVs). The CAV will then carry the payload through a maneuvering re-entry and deliver it to the target. The CAV will be subjected to a very intense re-entry environment, including high temperatures, high acoustic levels, high shock loads, and severe vibration loads. The payload and avionics must be protected from the severe environmental loads during the CAV launch, trajectory through space, final re-entry, and maneuvering flight to the target. Payloads and avionics can experience temperature extremes of about 300°F (due to propagation of aerodynamic heating through the vehicle shell into the avionics and payload compartments), acoustic loads as high as 175 decibels, shock loads as high as 5,000 g, and vibration loads as high as 150 grms. The materials used in this system should ensure that the payload and avionics temperature does not exceed 125°F, as well as reduce acoustic, shock, and vibration loads by 50-90%. The candidate materials for this system should be easily formable or shaped, have a maximum density of 10 pounds per cubic foot, and capable of using standard mechanical attachment methods to the CAV airframe. This material could also have future commercial applications as a shipping container for sensitive materials and devices or thermal isolation systems for heat generating components.

Phase I: Conduct a concept feasibility study on candidate materials and designs. Select material for testing and define testing methodology. Model the conceptual design and analyze the results through comparison with lab experimentation.

Phase II: Further refine the Phase I results by designing, developing, and demonstrating a prototype isolation structure and test for thermal, acoustic, shock, and vibration tolerance. Define acceptable interior and exterior environments for the structure. Demonstrate the feasibility of the Phase I design and validate the performance through modeling and lab demonstration.

Dual Use Commercialization Potential: Fabricate a full-scale payload isolation structure to provide isolation for three of the new 250-pound class Small Diameter Bombs (SDB) under development by the Air Armament Center at Eglin AFB, FL. Attach the structure to a CAV mockup and use the testing methodology developed in Phase I to define the actual environment the three SDBs will see on re-entry. Develop plans for constructing isolation structures for other CAV payloads, including a unitary penetrator and wide area munitions and also for a notional CAV avionics package. The isolation structures may also have applications as shipping containers, commercial electrical bus isolators, commercial aircraft insulation, automobile electrical system isolation and shielding, and commercial ELV insulation. Phase III will develop plans for acquisition and production of isolation structures for all selected CAV payloads and avionics packages.

Related References:
1. Air Force Space Command Strategic Master Plan for FY02 and Beyond, 9 February 2000.
2. Air Force Space Command Concept of Operations for the Phase I Space Operations Vehicle System, 6 February 1998.

3. Technical Report, Launch Vibration Isolation System (LVIS), D.L. Edberg, McDonnell Douglas Aerospace, April 1997.

KEYWORDS: Acoustic Isolation, Shock Isolation, Vibration Isolation, Materials Manufacturing, Lightweight, Materials, Spacecraft Protection

AF03-020 TITLE: Fine Steering Mirrors for Free Space Optical Communication Systems

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop compact fine steering mirrors (FSM) capable of greater than 5 kHz bandwidth with sub-microradian pointing accuracy in a power efficient design.

Description: Free space optical communication systems require high accuracy pointing systems due to the much narrower beam divergence compared to RF technology. Mechanical beam steering mirrors are typically used to enable this accurate pointing and, because of platform vibration and jitter, they must be able to mitigate high frequency components up to several kHz. Standard voice-coil actuated and other electro-mechanical devices are able to perform to these requirements but are typically very bulky and consume several Watts of electrical power. Alternative technologies based on micro-electro-mechanical (MEMS) devices or optical phased arrays are becoming available and promise to offer similar performance with significantly reduced power requirements. The application of these and other technologies to airborne or spaceborne optical communication systems would greatly reduce the overall size and power of such systems. To this end, the development of novel compact, power efficient fine steering mirrors is solicited.

Phase I: Examine a specific innovative FSM technology and develop a concept and design to address the free space optical communication requirements of sub-microradian pointing and greater than 5 kHz bandwidth. It is also desirable to have angle readouts to assist initial pointing (during the acquisition process) or for general health monitoring during operation, a typical performance for these readouts is 10 micro-radian accuracy at 30kHz. Identify power and size benefits of the technology compared to state of art. If possible, a prototype should be developed to verify the functional performance.

Phase II: Further development and testing of a prototype should be completed. Optimize the device design and fabrication and deliver a prototype beam pointing system.

Dual Use Commercialization Potential: These fine steering mirrors will support low-mass, low-power-consumption space terminals for future DoD, NASA and commercial space-to-ground and inter-satellite optical communications links. Other dual use applications include: laser radar, laser rangefinding, and laser illumination.

Related References: Bates, Regis J. “Optical Switching and Networking Handbook”, 2001, McGraw-Hill.

KEYWORDS: Optics, Laser Communications, Fine Steering Mirrors, Micro-Electro-Mechanical System (MEMS), Optical Phased Arrays, Optical Communications

AF03-021 TITLE: Precision Control of Fast Steering Mirrors for Laser Communications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop/validate designs for advanced high-precision fast-steering mirrors for free-space laser communications.

Description: Free-space laser communications is of potential value for satellite-to-satellite optical links as well as uplinks and downlinks. Optical components for terrestrial communications systems have been demonstrated at bandwidths that would be of significant value for satellite communications. However, satellite optical communications systems have needs for components that are not necessary in the terrestrial environment. One example is a need for precision pointing at relatively high bandwidth. Unless the laser communications beam can be precisely pointed at the receiver of interest, the optical beam must be significantly oversized at a cost of much higher required optical power. The need for precision pointing requires a high-speed fine-steering mirror to allow sufficient control to precisely point at objects in motion with respect to the satellite frame of reference. One of the limiting features of fine-steering mirrors for satellite communications involves encoding schemes. Optical encoding schemes are precise, but are susceptible to the space radiation environment. Capacitive encoding schemes are less vulnerable to radiation, but do not have the precision of the optical schemes. Novel encoding schemes that embodied precision as well as radiation tolerance would be of value to space systems. This request for proposal is aimed at innovative approaches or designs that specifically improve the performance of fast-steering mirrors for space applications by hardware or software or hybrid hardware/software approaches.

Phase I: Develop and validate innovative designs (hardware, algorithms, software, encoding schemes, etc) for precision pointing (sub-microradian, kHz bandwidth) of fast steering mirrors. Initial efforts should focus on conceptual design and simulation to validate the design. These efforts should include proof-of-principle validation of the survivability and performance of a fine-steering mirror structures consistent with applications of interest to military space programs.

Phase II: Apply the results of Phase I to the design, fabrication, and experimental validation, and optimization of a prototype fine-steering mirror system. Proposals facilitating the use of such devices to applications of greatest utility to military applications will be ranked highest.

Dual Use Commercialization Potential: Fast fine-steering mirror systems will certainly be of value to commercial satellite systems employing free-space laser communications as well as for DoD systems. High-speed fine-steering mirrors will also benefit laser micro-machining systems now coming online where precision pointing is important for micromachining for fabrication of commercial microelectronics and photonics components.

Related References:

1. Lambert, S. G., and Casey, W. L., Laser communications in Space (Artech House, Norwood, MA, 1995).
2. Portillo, A.A., et al, “Fine pointing control for optical communications,” 2001 IEEE Aerospace Conference Proceedings Part: vol.3 , Page: 3/1541-50 vol.3 (2001).
3. Moon, S.-M. and Clark, R.L., “Advanced methods for optical jitter suppression using acoustic actuators,” Proc. SPIE 4331, 72-81(2001).
4. Mujun X., et al, “Design and experiment of a LQ controller used in high-bandwidth fast-steering mirror system,” Proc. SPIE 4025, 250-258 (2000).

KEYWORDS: Free-space Laser Communications, Precision Pointing, Position Encoding, Optical Encoding, Capacitive Encoding, Bandwidth

AF03-022 TITLE: Efficient Electro-optical Modulators for Microwave/Photonic Intra-satellite Links

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop/validate designs for efficient electro-optical modulators for microwave-photonic intra-satellite links.

Description: Efficient high-speed electro-optic modulators are needed for on-board satellite fiber-optic data buses and other communications systems. Electro-optical modulators exist with bandwidths high enough to significantly enhance performance of on-satellite photonic links. However, other characteristics of these devices need to be improved to facilitate their use in intra-satellite applications. In recent years, new polymer material modulators have shown promising results and increased performance has been attained in more conventional lithium niobate modulators. There are several key performance parameters that need to be addressed for space applications, including lowering driving voltage (Vƒà) at high modulation bandwidth, reducing the fiber-to-fiber loss (insertion loss), and increasing the extinction ratio. Due to the high demand for optical modulators in the telecommunications industry where low cost, rather than high efficiency, is the primary driver, little has been done to improve the performance of these devices, especially in the area of insertion loss. This request for proposal is aimed at innovative approaches or designs that specifically improve the performance of this device for space applications. Specific approaches to advancing the design of the waveguide regions that match the waveguide mode to that in the optical fiber and/or electrode designs for increased efficiency and higher extinction ratios while maintaining high bandwidth are being solicited in this proposal.

Phase I: Develop and validate innovative designs for wide-bandwidth (>20 GHz) electro-optical modulators with low insertion loss and/or low driving voltage (Vƒà). Proposals should focus on the development of novel geometrical designs such as advanced tapered couplers; designs incorporating photonic bandgap structures and/or other nanostructures; designs incorporating gradient index materials or other novel materials; or other approaches to improve the state-of-the-art in insertion loss and/or driving voltage (Vƒà). Initial efforts should focus on conceptual design and development and characterization of test structures to validate the design. These efforts should include proof-of-principle validation of the survivability and performance of electro-optical modulators for systems consistent with the use of microelectronic devices for applications of interest to military space programs.

Phase II: Apply the results of Phase I to the design, fabrication, and experimental validation, and optimization of a prototype electro-optical modulator with low insertion loss and/or low Vpi. Proposals facilitating the use of such modulators to applications of greatest utility to military applications will be ranked highest.

Dual Use Commercialization Potential: More efficient electro-optical modulators will certainly be of value to terrestrial telecommunications companies as well as for DoD systems including satellites, aircraft, ships, armored vehicles, etc.

Related References:
1. Garner, S.M., et al, "Vertically integrated polymer waveguide device minimizing insertion loss and Vpi,¡¨ Proc. SPIE 3491, 421-426 (1998).
2. Kobayashi, R., et al, "Theoretical analysis of the sensitivity of electric field sensors using LiNbO3 optical modulator,¡¨ Electronics and Communications in Japan, Part I (Communications) 80, 79-89 (1997).
3. Lee, H.-Y., et al, "High performance electro-optic polymer waveguide device," Appl. Phys. Lett. 71, 3779-3781 (1997).
4. Camargo Silva, M. T., and Calligaris, A. O., Jr., "Electrorefraction type optical intensity modulator without interferometric device," Conference Proceedings ¡V Lasers and Electro-Optics Society Annual Meeting v1 1995, pp. 128-129.
5. Yu, P. K. L., et al, "Design and fabrication of InGaAsP/InP waveguide modulators for microwave applications,¡¨ Proc. SPIE 1703, 304-312 (1992).

KEYWORDS: Electro-optical Modulator, Insertion Loss, Driving Voltage, Mach-Zehnder, Electro-absorption, Wideband

AF03-023 TITLE: Optical Network Devices and Protocols for Space

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop and demonstrate innovative designs for intelligent broadband space based optical communications networks that include the network architectures, communication protocols and optoelectronic components for space systems applications.

Description: In order to accommodate the broadband data handling requirements of high resolution space based sensors and to enable multi-satellite constellation architectures, it is necessary to develop fiber optic intra-satellite networks and free-space optical inter-satellite networks that interoperater intelligently and adaptively. The integration of optoelectronic devices into multi-chip modules (MCMs) or monolithic devices, enables data transmission at rates exceeding 10 gigabits per second and avoids many of the bottlenecks associated with current networks. Although a few fiber optic components have been qualified for space applications, these devices are limited to low bandwidth (1 to 20 Mbps) intra-satellite command and control applications such as AS-1773. In addition, it is not possible to integrate the currently available intra-satellite data handling networks and the inter-satellite cross-links into interoperable space based communication networks. The ideal network would manage both the inter-satellite free-space laser communication links and the intra-satellite fiber optic data handling networks to enable intelligent and adaptive broadband satellite communication networks. These networks could provide a seamless all-optical interface between the external and internal optical links, or alternatively, be designed with optical-to-electrical transceivers. In either case, the key to the success of a space based optical network is its efficiency in producing optimized high-speed data transfers and real-time multi-access across all platforms including multiple satellites in constellations and high-speed subsystems within individual satellites.

Phase I: Develop and validate the feasibility of optical satellite communication networks that intelligently and adaptively integrate broadband intra-satellite and inter-satellite communications. Evaluate the capability of these optical satellite communications networks to interoperate with existing broadband commercial communications networks and protocols including the telco ATM/SONNET and internet TCP/IP based networks. Identify the advanced optoelectronic devices and communication protocols necessary to implement these networks. Define a development and validation plan that demonstrates the broadband data handling capability and interoperability of these networks.

Phase II: Design, fabricate and demonstrate the key optical network prototype components and network communication protocols developed in Phase I. Demonstrate the interoperability and adaptability of the inter-satellite and intra-satellite networks. Demonstrate the capability of the networks to interoperate with existing commercial networks and protocols.

Dual Use Commercialization Potential: The optoelectronic devices and network designs will be of high interest to designers of both DoD and commercial satellite systems. The devices, firmware, software, subsystems and development tools represent a significant opportunity in both Government and commercial aerospace applications.

Related References:

1. Schow, C. L., et al, “A monolithically integrated 1-Gb/s silicon photoreceiver,” IEEE Photonics Technical Letters. vol. 11, 120-121 (1999).
2. Kazlas, P., et al, “Monolithic vertical-cavity laser/p-I-n photodiode transceiver array for optical interconnects,” IEEE Photonics Technical Letters. vol. 10, pp. 1530-1532 (1998).
3. K. Araki, et al, “Results of ETS-VI satellite communications experiment,” J. Comm. Res. Lab. 44, 209-223 (1997).

KEYWORDS: Optical Networks, Optoelectronic Devices and Interconnects, Free Space Laser Communications, Space Environment, Radiation Effects

AF03-024 TITLE: <u>Infra-red Avalanche Photodiode Detectors (APD) for Laser Communications</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop low-noise, large-area, high quantum efficiency Avalanche Photodiode Detector (APD) sensitive in the 1064-nm and/or 1550-nm spectral region.

Description: Future high bandwidth satellite communications will utilize free-space lasers. Lasercomm terminals on satellites and terrestrial assets (air and ground, mobile and fixed) will permit high bandwidth, low probability of intercept, and jam resistant communications between satellites (crosslinks), and between satellites and ground/air assets. For links from space to ground, ground station site diversity is an operational strategy that mitigates the effects of cloud cover and increases the availability of the optical channel. This strategy, in which ground receivers are deployed in different weather cells (~200-km separation), will enable reliable high-bandwidth satellite-to-ground optical communications. Because of the number of stations required, ground stations will need be small (less than 1-m aperture), low-cost, and must operate autonomously. The stations are therefore not expected to be equipped with advanced atmospheric turbulence compensation equipment. High-bandwidth, large-area detectors that support gigabit per second data rates can mitigate the blurring effects of aberrations caused by atmospheric turbulence. High-quantum efficiency, low-noise detectors reduce the required transmitted optical power to that afforded by coding and the highly directional optical link. Segmented or multi-detectors enable beam tracking by using feedback from intensity differences between the segments/pixels.

Phase I: Survey existing detectors and assess the limitations imposed by physics on the development of a high quantum-efficiency (>50%), low-noise (comparable to silicon devices), IR (1064-nm and/or 1550-nm) APD detector. Understand the trade space of the detector performance. Develop strategies to incorporate high quantum-efficiency and low-noise characteristics into a high bandwidth (>3GHz), large-area (~ 200 um dia.) device. Explore options and techniques to enable segmented or multi-detectors. Design a prototype and assess its performance.

Phase II: Fabricate a prototype detector and test its performance. Compare theoretical predictions and experimental results explain any differences. Propose and describe in detail methods to improve the detector performance.

Dual Use Commercialization Potential: These detectors will support low-mass, low-power-consumption space terminals for future DoD, NASA and commercial space-to-ground and inter-satellite optical communications links.

Related References:
1. Jha, Asu Ram "Infrared Technology: Applications to Electro-Optics, Photonic Devices and Sensors" 2000, John Wiley & Sons.
2. Rogalski, "Infrared Detectors", 2001, G & B Science.

KEYWORDS: Optics, Laser Communications, Infrared Detectors, Crosslinks, Avalanche Photodiode Detector

AF03-025 TITLE: Multibeam Optical Communications Transmitter/Receiver

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop gimbaled lasercomm optical head capable of simultaneously transmitting multiple diffraction limited collimated beams within approximately 2 degrees of each other.

Description: Future high bandwidth satellite communications will utilize free-space lasers. Lasercomm terminals on satellites and terrestrial assets (air and ground, mobile and fixed) will permit high bandwidth, low probability of intercept, and jam resistant communications between satellites (crosslinks), and between satellites and ground/air assets. Typical laser terminals employ small (< 20cm) gimbaled optics that acquire and track each other, through closed loop control on beam intensity or a co-aligned beacon. Since the beams are very small, on the order of 10 micro-radians, these terminals can form only a single link, so that a separate transmitter is required for each link if multiple simultaneous links are required. There are several applications where a few ground/air or space terminals requiring service may be in close proximity, particularly for links from satellites to airborne and ground elements deployed in a military theater or crosslinks between satellites in a dense constellation in the same plane. If the satellite lasercomm optical telescope were such that it could form separate beams to serve each of these terminals, there would be a potential mass and cost savings compared to having separate optical heads to serve each. Innovative ideas are sought that would allow several different laser sources to use the same gimbaled optics to form several collimated beams of approximately 2 degrees separation (from GEO (Geosynchronous Earth Orbit), this is 1400km separation, and from 10,000km is approximately 400km). The goal is to achieve diffraction limited performance for multiple beams, using the same gimbaled optics. The device should enable cost and mass to be less that of multiple separate heads. The concepts must address the challenges of acquisition and tracking control for the separate beams.

Phase I: Survey existing lasercomm optical devices and performance requirements. Develop multi-beam optical designs, identify pointing control schemes for the various beams. Evaluate alternative designs including deformable mirrors and refractive optics. Compare cost, mass and performance to conventional approaches.

Phase II: Fabricate and test a brassboard optical terminal for multi-beam laser comm. Simulate lasercomm inputs and verify performance of optical beam forming and pointing control schemes over desired performance envelope. Evaluate production costs and space qualified unit mass.

Dual Use Commercialization Potential: Commercial communications satellite constellations (LEO, MEO and GEO) could benefit from a multibeam lasercomm terminal to reduce weight and cost of satellites. These terminals could support diversity in downlink/uplink from gateways to limit atmospheric attenuations/outages and could simplify the crosslink to satellites in the same ring of the constellation.

Related References:
1. Vasil'ev, Peter, Ultrafast Diode Lasers : Fundamentals and Applications Artech 1995.
2. Alexander, Stephen B., ?Optical Communication Receiver Design? 1997, SPIE.

KEYWORDS: Optics, Laser Communications, Multi-beam, Adaptive Optics, Optical Transmitter, Optical Receiver

AF03-026 TITLE: Millimeter Wave, Low Noise Amplifier

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Design and fabricate a single channel Low Noise Amplifier (LNA) in the millimeter wave band.

Description: Broadband LNA's are an essential component in communications satellites and terminals where gain and wide frequency range of operation are crucial to meeting performance requirements. Although a wide variety of LNA's are currently available in the frequency bands below 50 GHz, little development has occurred in the 49 to 52 GHz range. In order to meet projected growth for satellite capacity in the coming decades, commercial and military satellites will need to access spectrum available at V-band (36-60 GHz). The purpose of this topic is to develop a high performance prototype of an LNA capable of operating over the on-orbit operating temperature range of -40° C to +80° C. Additional goals include process and design enhancement for environmental hardening (including radiation), noise immunity, and reliability.

Phase I: Design a single channel, broadband LNA. Performance goals include gain of 30 dB; .flat (+/- .3 dB) response between 49 and 52 GHz; and with a noise figure < 1.5 dB.

Phase II: Fabricate a prototype of the LNA and characterize over temperature. Characterization should include gain vs. frequency, gain vs. temperature, noise figure vs. temperature.

Dual Use Commercialization Potential: Due to spectrum limitations at the lower bands, both commercial and military satellites can be expected to utilize the millimeter wave bands once the technology becomes available to transmit and receive at these frequencies.

Related References:
1. Daniel, Luca, Terrovitis, Manolis, "A Broadband Low-Noise-Amplifier", May 1999, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley.
2. Carson, R.S. "High Frequency Amplifiers", 1982, Wiley.
3. Gonzales, Guillermo, :Microwave Transistor Amplifiers - Analysis and Design", Prentice-Hall, 1984.

4. Battaglia, "Design A Low-Noise Communications Amplifier", Microwaves and RF, Dec 99. www.planetee.com/planetee/servlet/DisplayDocumentArticleID=9126.

KEYWORDS: Amplifier, Noise Figure, Broadband, Gain, MMIC, Millimeter Wave, LNA

AF03-027 TITLE: Space Qualifiable Beam Control Driver Electronics

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop technologies for flight/space qualifiable, lightweight, low power drives for adaptive optics and rotary actuators.

Description: There is a need to explore new ideas and develop the next-generation of electronics to control and drive wide-bandwidth deformable mirrors (DM) and fast steering mirrors (FSM). Preliminary analysis of the Space Based Laser / Integrated Flight Experiment (SBL/IFX) Beam Control Element (BCE) shows that power consumption by the mirror actuators and drives during standby operation constitute three-fifths (3/5) of total BCE power consumed. These drivers belong to a generic class of device that can control a wide variety of capacitance based piezoelectric mechanisms that can have wide military and commercial applications. The actuators and corresponding drivers for high-energy laser adaptive optics systems have historically been specialized with a bulk of the operation confined to benign ground based environments and a small base of users, thus limiting the necessity for the development of light weight, low power systems. Current state of technology for a 350-channel deformable mirror driver would require about one-half of a six-foot 19-inch rack or 31,104-in3 and between 800 to 1200 Watts of quiescent and operational power dissipation, respectively. This translates to about 90-in3 per channel and 39-mW/ in3. In order for space-based high-energy missile defensive systems to be viable, it is imperative that efficient and lightweight actuator drivers be developed. To achieve efficiency, weight, and volume goals for adaptive optics drivers, a greater than one order of magnitude reduction is required. A similar challenge for small volumes combined with lower peak voltages is needed for analogue high torque, low speed rotary actuators for usage in mechanical structures and vehicles. These driver electronics requirements will require considerable ingenuity and innovation in flight/space qualifiable electronics design, new packaging concepts and the possible application of new and advanced materials for achieving electrical performance, thermal efficiency and dissipation.

Phase I: Conduct an analysis/review of current high-energy laser adaptive optics actuators, rotary actuators, and their respective drivers. Performance requirements and constraints for use in space shall be identified and a reference list will be generated. A study shall be performed, a comparison made of all existing possible solutions with limitations associated to each. A design for a DM and FSM driver will be selected for simulation and prototype development. Evaluation and testing methodology shall be defined to demonstrate the feasibility of the adaptive optics driver concepts.

Phase II: Fabricate an integrated component, such as a mixed signal Application Specific Integrated Circuit and prepare a path to produce a space hardened driver. Construct testing hardware and use the methodology developed in Phase I to test the driver performance. Two prototypes shall be built using discrete components to demonstrate functionality of the concept. The final, integrated designs using the results obtained from the prototypes will then be generated and tested. Develop plans for driver production using radiation tolerant/commercial processes.

Dual Use Commercialization Potential: Besides immediate military customers for this technology, these drivers, used in conjunction with piezoelectric or electrostatic rotary actuators, can produce high-torque at low speed, thus allowing for direct drive actuators for fly-by-wire systems. Successful implementation with efficient, advanced drivers may provide more reliable and programmable mechanisms for aircraft and vehicle uses that use cleaner lubricants.

Related References:
1. Smart, David L., “A switching Amplifier for Capacitive Loads Using Incremental Resonant Charging”, IEEE 1979.

2. Ehsani, Mehrdad, United States Patent - 5,852,358, “Capacitive Power Circuit” December 22, 1998.

KEYWORDS: Actuator Driver(s), Adaptive-optics, High-energy, Laser, Piezoelectric, Voice Coil, Electro-strictive, High-torque

AF03-028 TITLE: Nano/Micro Technologies for Particle Sensing in the Space Environment

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

Objective: Develop ultra lightweight low power particle sensors or component technology to support Space weather mission using micro/nano-satellites.

Description: Space situational awareness demands sensors for thermal and energetic particles (electrons, ions, energetic neutral atoms, and molecular species) that can be deployed on micro- and nano-satellites in environments ranging from LEO to GEO and beyond including the solar wind. AF concerns include both the natural space and battlespace environments focusing on those particles and fields that affect space weather and the survivability of DoD space assets. The environmental concerns include electric and magnetic fields, ions and electrons from thermal to relativistic energies, and thermal and energetic neutral atoms. Novel sensing and selection technologies are sought to support the ultimate goal of producing spacecraft sensor packages that are at least an order of magnitude lighter than existing operational sensors while maintaining sensitivity and data quality. Concepts to be pursued include novel instrument designs as well as break-through component technologies such as solid-state detectors that reject energetic photons while exhibiting sensitivity to particles; sensors based on the response of micro and nano-circuits to particle impact, and miniaturized position sensitive detection approaches. Concepts for incorporating such sensors in spacecraft surfaces to increase the sensing aperture are also desired. Although the topic thrust is to support breakthrough technologies, evolutionary approaches will be considered.

Phase I: Develop conceptual designs and/or bench-level devices that can establish feasibility. The Phase I products should be useful for estimating the scope and cost of an actual flight test experiment, or in the case of component technology provide estimates of performance specification and a technology path for manufacturability

Phase II: Delivery of a working prototype of the device or technology is anticipated. The level of finish may range from a bench-top device suitable for evaluation to a flight-ready system depending on the complexity of the proposed effort. Proposals should clearly state the intended deliverables. The AF may sponsor access to space for selected flight ready systems. At a minimum, the effort shall provide for proof-of-principle demonstration in the lab or space and establish commercial viability as a prerequisite to Phase III continuation.

Dual Use Commercialization Potential: Potential military applications will include expendable multi-mission payloads produced in large volumes. The overlap between DoD and civilian space weather missions make this effort inherently dual use. There should be significant commercial potential in supplying technology to those missions which include magnetospheric mapping and solar warning. In addition, miniaturization efforts are well known for unanticipated spin-offs.

Related References:
1. "Energetic Neutral Atom Imager on the Swedish Microsatellite Astrid", S. Baradash, et.al., in Measurement Techniques in Space Plasmas: Fields, Geophysical Monograph 103, p. 257, Am.Geophys Union, 1998.
2. "Compact Environmental Anomaly Sensor (CEASE): A Novel Spacecraft Instrument for In Situ Measurement of Environmental Conditions", B.K. Dichter, et. al., IEEE Trans. On Nuc. Sci. Vol 45, NO 6, Dec 1998.
3. “Charged-coupled devices for charged-particle spectroscopy on OMEGA and NOVA”, C.K. Li, et.al., Rev. Sci. Instrum. 68 (1), p 593, Jan. 1997.
4. “Medium Energy Neutral Atom (MENA) Imager for the IMAGE mission”, C.J.Pollack, et.al., Space Science Reviews Vol. 91 Nos. 1-2 2000, ed. by J.L.Burch.

KEYWORDS: 1. Microsatellite or Nanosatellite and Sensor, Charged Particle Detector, Space Weather. Charge Coupled Device, Energetic Neutral Analyzer, Nanotechnology, Single Electron Amplifier

AF03-029 TITLE: Small Satellite Bus Technologies

TECHNOLOGY AREAS: Electronics, Space Platforms

Objective: Develop an integrated small satellite (approximately 10kg) bus capability.

Description: Multiple interests within the United States, including the Department of Defense (DOD), NASA, Universities, and industry have an interest in using small satellites to perform space experiments, demonstrate new technology, and test operational prototype hardware. In addition, the US Government space community is actively pursuing small satellite constellations to fulfill mission requirements. One of the obstacles to the development of small satellites is the lack of a standardized small satellite bus architecture. Several recent technology development efforts have been focused of specific miniaturized satellite component subsystems. However, to date, no concerted effort has been focused on the development of a standard small satellite bus architecture. This architecture would provide a complete satellite capability, minus whatever experiment(s) are selected for a specific mission.

This effort will focus on the identification and integration of all of the satellite subsystem components necessary to provide a small satellite experimenter “plug-and-play” capability. It is anticipated that several subsystem technology development efforts may be required to complete the bus architecture. The end product of this effort is envisioned to be a complete small satellite, including a full suite of standard satellite components (structure, communications, attitude determination/control, power conditioning and distribution, central processing unit/operating system/data storage, thermal, etc.) minus the experiment(s).

A primary focus of this effort will be the development and integration of miniaturized satellite components into a functional bus system, which will allow for an experiment plug-and-play capability in the small (approximately 10kg total mass) satellite class.

As part of the effort, a survey of typical experiment requirements will be explored, and included in the standard bus architecture. It is suggested that the survery be limited to low earth orbit (LEO) experiments.

Phase I: Phase I will consist of a period of research into the state of the art of flight qualified and flight qualifyable small satellite bus components, including the systems engineering and integration of these components into a small satellite bus architecture.

Concepts will be developed to adapt and flight qualify any existing small satellite component technologies identified. New designs will be generated for capabilities that do not exist. Development and integration plans for new components/concepts will be outlined. An assessment will be made of the state of the art in methods, equipment, and operation for small satellite bus components.

Phase II: Phase II will consist of the development and flight qualification of the integrated small satellite bus concepts identified in Phase I. Operating procedures will be developed and documented to enable future missions. Where possible, specific mission requirements, both government and commercial, will be used as design guidelines.

Dual Use Commercialization Potential: The small commercial spacecraft market is expected to grow significantly over the next decade, including DOD, NASA and commercial applications. Markets include commercial and military communications and imaging satellites and inexpensive experiment platforms for the DOD and NASA – leading to full scale science and military operational missions.

Related References:
1. The Role of Small Satellites in NASA and NOAA Earth Observation Programs, Committee on Earth Studies – Space Studies Board, ISBN 0-309-06982-3, National Research Council.
2. “AFRL’s Multi-Satellite Deployment System”, CE Brackett, 15th Annual AIAA/USU Small Satellite Conference, Aug 13-16, 2001, Logan UT.
3. "Small Satellites (MSTI-3) for Remote Sensing: Pushing the Limits of Sensor and Bus Technology," W Jeffrey, Proceedings of SPIE, 1995; v.2317, p.206-216.
4. "A Proposed On Orbit Demonstration of an Advanced Pulsed Plasma Thruster for Small Satellite Applications," D Bromaghim, IEEE Conference Proceedings, Mar 18, 2000, Big Sky MT.

KEYWORDS: Small Satellites, Miniaturized Satellite Technologies, Micro/Nano/ Satellites, Satellite Bus Technologies

AF03-030 TITLE: Integrated MEMS Switch Packages for Space Systems and Communications Architectures

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

Objective: Develop packaged micro-electromechanical systems (MEMS) switches capable of withstanding space radiation environments, emphasizing full switch functionality and manufacturability.

Description: Space systems require increasingly complex electronics that must reliably operate in the space radiation environment. Switching techniques have been developed which enable redundant systems, reconfigurable spacecraft, and communications. Reliable switches and switch arrays are needed for these systems. The use of MEMS switches, either singly or in switching arrays, will allow such systems to operate reliably, requiring little power. MEMS switches are increasingly being used in military and commercial systems, and research is continually being done to improve the reliability of these switches. Further development of switching arrays, power bus switches, and radio-frequency (RF) switches is required. In the area of switching arrays, such specifications as a density >100 switches/square millimeter (mm2), current handling capacity = 1 ampere (A), time to switch < 5 milliseconds (ms), constriction resistance < 50 milliohm (m-ohm), switching energy < 1 millijoule (mJ), hot switching capability = 15 volts @ 10 milliamperes (mA), and lifetime > 1,000,000 cycles are required. For power bus switches, such specifications as current handling capacity = 10 A, time to switch < 10 ms, constriction resistance < 8 m-ohm, switching energy < 1 mJ, hot switching capability = 10 volts @ 1 A, and lifetime > 10,000 cycles are required. For RF metal-metal switches, such specifications as insertion loss < 0.05 dB below 10 GHz, switching capacity = 50 milliwatts (mW), switching time < 100 microseconds (ms), and lifetime > 10,000,000 cycles are required. Development of the MEMS switches described here is itself a daunting technical task. However, crossing over from the realm of switch development and manufacturing into the more useful world of switch production and utilization is being hampered by the issues surrounding the packaging of these devices. MEMS switches are not always designed with packaging in mind, and modern microelectronics production and packaging technology are not compatible with the "micromachines" of the MEMS world. When MEMS switches are packaged for use in systems and subsystems, the reliability and the yield of the production run of the switches decreases markedly. What is needed is a packaging method or methods that will allow the switches to operate reliably for their required lifetime, in the space environment, and will allow terrestrial evaluation of the packaged switches in simulated space environments. The design and development of integrated, packaged switches must necessarily be undertaken with large-scale production in mind, so issues relating to packaging materials, sealing, manufacturability, and testability must be considered. In addition, the packaging itself must not degrade the performance of the MEMS switches contained in them; for RF switches, the packaging must not add more than 0.05 dB signal loss at 10 GHz, and for the other switches and arrays, the packaging must not add more than 50 ohms pin-to-pin resistance. As these switches will be used in space systems, space environmental parameters, such as radiation levels, temperature, and pressure must also be considered. The development of packaged MEMS switches and switch arrays for use in space systems is solicited.

Phase I: Identify and define a specific MEMS switch design to meet the specifications of one of the three categories (switching arrays, power bus switches, or RF switches) described above. Identify and define the packaging technology to be used for packaging the specified MEMS switches, which will allow operation of the switches in the space environment. Determine the technical feasibility of integrating the MEMS switch with the packaging design, with the goals of manufacturability, testability, reliability, and availability.

Phase II: Develop, demonstrate, and validate a prototype MEMS switch that will operate in space systems, based on the technical design defined in Phase I. Emphasis should be placed on the large-scale manufacturing of the integrated switches, using the goals of Phase I as a guide. The contractor should conduct testing on the prototype switches to determine the level of conformance with the specifications defined in Phase I. Such testing should include lifetime and radiation response testing. The packaging should also be tested to determine pressure/vacuum (as required) in the MEMS switch cavity, and contamination of the switch due to particulate, water, or hydrocarbon residue from the manufacturing process. The design should allow independent testing by a qualified laboratory.

Dual Use Commercialization Potential: One application of these integrated MEMS switches would be for switching in redundant space electronics, to allow operate-through or circumvention capability in case of catastrophic radiation or other environmental events. Another would be in the area of reconfigurable spacecraft, or spacecraft systems, whereby a switch array would allow electronics such as signal- or data-processors to be reconfigured on orbit into a different function. Other uses include spacecraft communications and radar systems.

Related References:
1. W. P. Taylor and M. G. Allen, "A Fully Integrated Magnetically Actuated Micromachined Relay," Proceedings of the Solid-State Sensor and Actuator Workshop, Hilton Head, SC, (1996), pp. 231-134.
2. M. Ruan, J. Shen, and C. B. Wheeler, "Latching micro magnetic relays with multistrip permalloy cantilever," in The Technical Digest of the 14th IEEE International Conference on Micro Electro Mechanical Systems, 2001, pp. 224-227.
3. T. R. Hsu, Design, Manufacturing, and Packaging of Microsystems, Boston, MA, McGraw-Hill, 2001.
4. W. Nakayama, "Thermal Issues in Microsystems Packaging," IEEE Transactions on Advanced Packaging, v.23, no.4, Nov. 2000, pp. 602-607.

KEYWORDS: Micro-electromechanical Systems, MEMS, Switches, Electronics Packaging, Radiation Response, Integrated MEMS, Space Environment

AF03-031 TITLE: Polarization Phenomenology

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: Develop new polarization modeling software or develop new polarization instrumentation for use in understanding polarization phenomenology.

Description: AFRL is engaged in research and development to further the understanding of optical polarimetric phenomenology. One advantage of using polarization is that it can improve contrast for a number of target detection and discrimination applications. Emissive polarization can possibly be used to detect a target from background in an isothermal scene where conventional infrared sensors would detect little or no contrast. Of particular interest are the spectral polarization signatures of objects measured passively in outdoor environments.

Polarization phenomenology investigations must first start with an understanding of the raw polarization signatures from targets of interest. The emitted and reflected portions of the polarized light depend on the material characteristics of the target, such as surface roughness, index-of-refraction, and target geometry. The overall phenomenological studies must also take into account environmental variables that affect the polarization signal measured by a detector. Sky illumination is the most significant environmental variable that changes the apparent target signature, but influences of atmospheric propagation may also be present.
Because the environment can have a great effect on polarization signatures, modeling and simulation, incorporating material characteristics and environmental variables, will be used to develop a better theoretical understanding of the physics behind measured signatures and to predict polarization signature outdoors. With this in mind, the ability to perform target-to-sensor simulations of polarization measurement scenarios is required. Data from a controlled environment, showing raw polarization signatures, and field data, showing environmental effects, are being collected to validate specific models and the overall simulation.

AFRL is requesting proposals in two related areas. First is the development of new polarization modeling software packages that can be used in investigating polarization phenomenology. This package would aid in predicting polarization from surfaces, the atmosphere, or be an integrated predictor of the total polarization measured by a sensor. Second, AFRL is requesting novel approaches to building polarimeters for use in phenomenology studies. The needed polarimeters include full polarization, spectral capability, measure polarization simultaneously, and can be accurately calibrated. Since accurate data is needed for phenomenology, part of the potential effort would include investigating the calibration of the polarimeter system.

Phase I: Develop approaches for a polarization modeling software package or conceptual designs for a polarimeter suitable for phenomenology studies.

Phase II: Develop applicable and feasible prototype models, software, or instrumentation using the Phase I results and demonstrate a degree of commercial viability. Prototype software would be used to compare predicted polarization to some measured results. Prototype sensors would demonstrate capabilities and include a detailed plan for calibration.

Dual Use Commercialization Potential: Many military applications will benefit from using optical polarization, and thus will take advantage of the successful completion of the Phase II effort. Remote sensing with polarization has potential applications in the commercial market as well, particularly in improved environmental assessment.

Related References:

1. T.J. Rogne, F.G. Smith, J.E. Roce, "Passive Target Detection Using Polarized Components of Infrared Signatures," Polarimetry: Radar, Infrared, Visible, Ultraviolet, and X-Ray, J.W. Morris and R.A. Chipman, eds., Proc. SPIE, 1371, 1990.
2. L.B. Wolff, A Lundberge, R Tange, "Thermal Emission Polarization," Polarization and Remote Sensing II, D.H. Goldstein and D.B. Chenault, eds., Proc. SPIE, 3754, 1999.
3. M.P. Fetrow, D.L Wellems, S.H. Sposato, K.P. Bishop, and T.R. Caudill, M.L. Davis, E.R. Simrell, "Results of a new polarization simulation", Polarization and Remote Sensing IV, Goldstein and Chenault, eds., Proc. SPIE, 4481, 2001.

KEYWORDS: Polarization, Polarimetry, Remote Sensing, Modeling, Simulation, Validation Experiments, Spectral Polarization

AF03-032 TITLE: High Specific Power Solar Arrays from Nanoparticle Precursors

TECHNOLOGY AREAS: Electronics, Space Platforms

Objective: Develop crystalline thin-film solar cells on flexible substrates from nanoparticle precursors. The resulting solar cells would have higher specific power than current thin-film and multijunction cells (>1000 W/kg).

Description: Future space missions will require solar cells having specific power ratings in excess of 1000 W/kg. Conventional crystalline photovoltaic technology comprised of thin photovoltaic materials grown on semiconductor single-crystal wafers cannot provide these specific power ratings since solar input is only 0.135 W/cm2 and the mass of crystalline devices is 0.125 g/cm2. Thus crystalline photovoltaic devices, even with 40% efficiency, are limited to specific power ratings of approximately 400 W/kg. Thin-film devices, deposited on lightweight, flexible substrates, have the potential of providing higher specific power ratings, but ultimate efficiencies of thin-film solar cells are not expected to exceed 15%. A combination of crystalline thin-film photovoltaic layers having an efficiency >25% with a lightweight, flexible substrate would yield a specific power rating of >1200 W/kg. Currently, single crystal or near-single crystal films can only be grown on rigid single crystal wafers (resulting in 0.125 g/cm2) or on equally massive or fragile foreign substrates such as ceramics at temperatures >1000 ºC. Only polycrystalline or amorphous material can currently be deposited on lightweight metal foils and polymers. Grain boundaries in polycrystalline films are electrically active and limit cell efficiency by serving as recombination sites. However, it has been demonstrated that single-junction, polycrystalline GaAs cells can achieve efficiencies of 20%, provided that grain boundaries are sufficiently passivated and that grain sizes are 20 microns or larger. Grains of this size could be grown on low temperature substrates by the use of nanoparticle precursors. The melting temperature of nanocrystals is dependent on the size of the cluster and is a fraction of the bulk melting point, allowing for low temperature recrystallization. Previous work has shown that heat treatment of nanocrystals at their reduced melting temperature will result in coalescence of the nanoparticles, and molecular dynamics experiments have shown that liquid nanoparticles can coalesce onto larger solid particles or surfaces, resulting in growth of the larger crystal. Novel methods for nanoparticle heat treatment or deposition are sought that would result in a single crystal or large-grain crystalline thin film on flexible, lightweight substrates. The deposition or heat treatment techniques should inhibit small grain polycrystalline growth by discouraging unwanted coalescence between isolated nanoparticles. The crystalline layer or layers produced could be used as a template for further growth of photovoltaic device layers or the nanoparticle-derived layers could comprise the device itself. A suitable composition for the nanoparticle precursors would be GaAs or the nearly lattice-matched Ge, to allow eventually compatibility with GaAs and multijunction solar cells. Success of the effort will depend on attention to the chemical termination of the nanoparticles to avoid oxidation and to prevent organic contamination of the thin film.

Phase I: Design and develop an innovative method for forming a thin-film Ge or GaAs layer on a polymer or metal foil substrate. Produce a small-area prototype thin-film with >50 micron grain size and minimal contamination that would lead to high efficiency solar cell devices.

Phase II: Develop a method for producing large-grain crystalline solar cells on flexible substrates. Provide a ~1 cm2 photovoltaic device based on thin-film production method.

Dual Use Commercialization Potential: Dual use commercialization would occur through the development of high performance (W/kg and $/W) cells and arrays that could be used for terrestrial/space applications. Lightweight, high efficiency solar arrays will find applications on commercial and military spacecraft and as portable terrestrial power sources.

Related References:
1. C.-S. Yang, S.M. Kauzlarich, Y.C. Wang, and H.W.H. Lee, "Photoluminescence as a Function of Aggregated Size from n-Butyl-Terminated Silicon Nanoclusters", J. Cluster Sci., 11 (2000) 423-431.
2. B.A. Ridley, B. Nivi, J.M. Jacobson, "All-Inorganic Field Effect Transistors Fabricated by Printing", Science 286, (1999) 746-749.
3. A.N. Goldstein, "The melting of silicon nanocrystals: Submicron thin-film structures derived from nanocrystal precursors", Appl. Phys. A 62, 33-37 (1996).
4. R. Venkatasubramanian, B.C. O'Quinn, E. Silvola, et al., 26th Photovoltaics Specialists Conference, Sept. 1997, Anaheim, CA, 811-814.

KEYWORDS: Solar Cells, Power Generation, Thin-Film Photovoltaics, Satellite Electrical Power, Conversion Efficiency

AF03-033 TITLE: Solar Thermal Technologies for Orbit Transfer Vehicles and Space Mobility

TECHNOLOGY AREAS: Space Platforms

Objective: Develop light weight, long life solar concentrator technology, long duration cryogenic propellant storage technology, improved thermal to propulsion energy conversion technology, and technology enabling optimized maneuvers for high mobility solar orbit transfer vehicles.

Description: Develop advanced technology solutions for one or more of the following technical needs. 1) Solar Concentrators. For space vehicle applications including solar thermal propulsion, the parabolic solar concentrator reflectors must be lightweight, highly packageable, affordable, and have a life-time of 1-10 years on orbit. Past efforts have generated lightweight and packagable technology such as inflatable collectors. Other efforts have developed long life concentrators using segmented rigid mirrors. But lightweight, packagable, and long life have not all been achieved together as yet. Technology to rigidize inflatables or improve the mass and volume of deployables is needed along with improvements in the means of pointing and controlling the concentrators during thrusting operations. 2) Cryogenic propellant storage. The need here is to store bulk cryogenic hydrogen for 0.5 – 5 years with modest impacts to tank fractions and power requirements. Passive systems have been designed for storage up to 50 days through continuous use of the propellant. Improved passive and/or active cryo-cooler systems are needed to enable storage up to 5 years. 3) Thermal to propulsion energy conversion. This need is to improve on the means of converting the sun's energy into available thermal energy for propulsion uses. Currently a significant amount of energy is lost in the high temperature heat exchanger. Improvements in high temperature insulation and/or high temperature phase change materials are needed to store heat at 1800-2700k. 4) Optimum maneuver technologies.

For maneuvering vehicles with low thrust (solar thermal or solar electric), a method and software capability to plan and optimize major orbit changes is needed that can take into account low thrust, finite burn durations, variable Isp, power limitations (such as solar eclipse), and time constraints. The algorithms and methods can be analytical or numeric as long as they can be applied to a mission planner and are applicable to on-spacecraft calculation and execution.

Phase I: Define the methodology and technological approach that provides the desired capabilities for at least one of the areas of light weight cryogenic storage systems, long life concentrators systems, efficient energy conversion, and/or methods to plan space vehicle orbit changes that account for a low thrust variable Isp. By the end of phase I, adequate development of the technology must be achieved such that prototypes or simulations have proven the underlying principles. The results of this phase must include a development path and design that will provide a guide to Phase II activity, as well as an estimate of the cost, schedule, technical performance and risk of the demonstrated capabilities.

Phase II: Utilize the findings of Phase I to design, construct, test and operate a functional prototype that encompasses the performance goals of the desired engineering component development. Testing should be included that will demonstrate the performance in a sufficiently relevant environment to demonstrate capabilities. Inclusion of dual use market penetration planning.

Dual Use Commercialization Potential: Implement technology insertion into government and commercial venues. This would include integration with other existing components for grounds test or possibly incorporation into a space experiment.

This system and technology can be used for payload repositioning, refueling, orbit transfer, & satellite tug all of which have both commercial and military applications. The component technologies can also benefit high power space systems and ground based solar thermal applications.

Related References:
1. Kessler, T.L.; Frye, P.; Partch, R., “Solar Thermal OTV-Applications to Reusable and Expendable Launch Vehicles,” Acta Astronautica, Vol. 47, Issue2-9 July-November, 2000, pp. 215-226.
2. McClanahan, J.A.; Frye, P.E., “The Solar Thermal Propulsion Transfer Stage design for near-term science mission applications,” AIAA94-2999.
3. Fitzsimmons, Maj J., “Advanced upper stage options for future DoD missions,” AIAA94-4585.
4. Paxton, J.; Hawk, C.W., “Material property effects on thin film solar concentrator.

KEYWORDS: Solar Orbit Transfer Vehicle, Space Cryogenic Storage, Pointing and Tracking, Low Thrust Space Vehicle, Solar Concentrator, Solar Thermal Rocket, Orbit Change Maneuvers, High Temperature Phase Change, Inflatable Rigidization

AF03-037 TITLE: Autonomous Satellite Cluster Data Fusion

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Increase the level of satellite autonomy by designing and developing technologies which would enable the assimilation of multiple heterogeneous information sources across a cluster of satellites and provide intelligent decision making.

Description: The concept of using clusters of microsatellites to replace large monolithic satellites is a relatively new idea. With this new concept comes many new challenges which include how information is shared across the cluster and how communication with the ground is handled. At the present time there is very little automation on Air Force satellites. Large amounts of data are collected from each satellite and downlinked to the ground where a variety of independent techniques are used to assess whether there exists any information of value. In addition, there is virtually no collaboration between satellites with respect to position or knowledge about detected objects of interest.

The amount of data collected and downlinked could be severely reduced if more intelligence is placed on-board which has the ability to process, detect, and interpret information and adjust and/or configure sensors based on sensor data. The objective of this research effort is to develop an architecture which will enable knowledge sharing across a cluster of satellites. Each satellite in a cluster would have its own on-board satellite manager which would manage its own satellite activities. A higher-level cluster manager would manage the overall cluster activities. Each satellite's on-board controller would operate autonomously in cooperation with executive controllers on other satellites as well as ground-based controllers. Each of these controllers would act as top level intelligent agents. A key to this research effort is the ability of the individual spacecraft managers to cooperate with one another. For example, an agent residing on one satellite may detect some object of interest and react accordingly. To optimize information processing, relevant information can be made available to a second satellite such that when the object comes within its field of view it can already be configured to optimize observation of the object in question. The notion of an intelligent cluster manager can be extended to include health and status related satellite autonomy.

Phase I: Provide a detailed design and description for the architecture which will enable data fusion across a satellite cluster. This will include but not be limited to the mechanism by which knowledge is shared and the means by which a situational assessment is made based on the status of information sources. A prototype demonstration of the proposed architecture is highly desired.

Phase II: Implement the design generated in phase I and to provide an in-depth demonstration of its capability. The architecture should be designed such that it can be easily extended to incorporate new agents as needs arise. Demonstration of this extensibility/flexibility is desired. Demonstrating this technology in an actual flight experiment is ideal, however if time and cost prevent this then the demonstration should be as realistic as possible with an easy migration towards a flight experiment.

Dual Use Commercialization Potential: The concept of data fusion of heterogeneous information sources is not specific to satellite autonomy but has applicability to any number of different domains. Any process which involves monitoring a number of different entities from different sources and providing a situational assessment based on all of these entities could benefit from such an intelligent architecture.

Related References:
1. Zetocha, Paul, and Ortiz James, "Phillips Executive Agent-Based Controller Helper (PEACH)", Paper for SpaceOps 98 Conference, Sep 1997.
2. Nwana, Hyacinth, Software Agents: An Overview", UMBC Agent Web site - www.cs.umbc.edu/agents.
3. Hopkins, Kory, "An Examination of Agent Technologies", Simon Fraser University, Web Site - www.cs.sfu.ca/cs/people/GradStudents/khopkins/personal/papers/agent_readings/index.html.
4. Agent Technologies HomePage, www.agenttech.com.
5. Ballard Dan, "Intelligent Agents and Agent Communication Languages for Mission Operations", Phase I SBIR Final Report.

KEYWORDS: Intelligent Agents, Autonomous Agents, Smart Optical Sensing, Executive Controller, Agent Communications, Situation Assessment, Intelligent Satellite Control, Space Surveillance, Missile Plume, Optical Phenomena, Modeling and Simulation

AF03-041 TITLE: Integrated Aircrew Ensemble

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Aeronautical Systems Center (ASC)

Objective: To develop an Integrated Aircrew Ensemble which integrates with existing and future Life Support and Escape systems.

Description: Technological advances with aircrew flight gear have not kept pace with introduction of higher performance aircraft and the increasing physiological demands placed on aircrew members. Currently, aircrew members are faced with donning multi-layers of equipment causing heat stress and reduced mobility. As equipment

items are often developed to mitigate specific threats or provide a performance capability, multiple configurations of equipment ensembles exist, each specific to a given mission and level of protection. The current environment requires a multitude of protection capability from Nuclear Biological and Chemical to Fire, heat, smoke, and cold dry/wet exposure hazards. Flight gear must also provide G-loss of Consciousness (LOC) protection for high performance aircraft and integration with oxygen delivery, escape and bladder relief systems. Further research is needed to analyze and develop concepts/solutions to an integrated ensemble that reduces bulk and thermal stress giving required aircrew protection, performance, and mobility. Consideration should be given to
incorporating lightweight breathable materials and/or fewer material/garment layers, thus reducing bulk and weight. Advances in this area may require a paradigm shift away from traditional pneumatic bladders, and towards the use of "active/smart materials".

Phase I: Perform a technology feasibility assessment and deliver a description of the conceptual solution and a technology/technologies development proposal.

Phase II: Execute the technology development plan proposed in Phase I and demonstrate the solution by delivering a prototype Aircrew ensemble. The technology assessment should review commercially available processes and products for applicability and consider commercial research and development efforts. While direct commercial applications may be limited with respect to a full-integrated ensemble, there are commercial markets that deal with certain facets of protection and performance, i.e. fire fighter gear, cold weather gear, under water gear, etc. Technology, processes, products, and treatments applied to these items may be applied to the aircrew ensemble solution.

Dual Use Commercialization Potential: Processes and/or products developed under this effort may be applied to existing commercial markets. End users include the services, government agencies, and foreign military (NATO and FMS).

Related References:

1. Aviation Medicine third addition, Ch.10 Protection against long duration acceleration pp148-156, Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford OX2 8DP, edited by John Ernsting, 1999.

2. http://www.sbccom.army.mil/products/cie/Adv_Lt_CB_Uniform.htm

3. http://www.brooks.af.mil/HSW/YA/YAC/YACL/atags.htm

4. Nordwall BD. Novel anti-G suit protects with liquid. Aviation Week & Space Technology. 2001 (Augusti 3); 2 p

5. Active Textiles for Life Support Ensembles and Medical Applications, LLC, PhaseI NSF SBIR Grant #DMI-9961132, Final report 7/11/2000, Authors: J.S.N. Paine, E.J. O'Malley, N. Samuelson, and M.E. Johns

KEYWORDS: Integrated aircrew ensemble, Thermal burden, Bladder relief, Flight gear, Positive Pressure Breathing for G, Full coverage anti-G suits, Smart Materials

AF03-042 TITLE: Improved Low-Cost Helmet-Mounted Display for Mission Simulations

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Aeronautical Systems Center (ASC)

Objective: Develop a low-cost, helmet-mounted device to improve pilot situational awareness in virtual simulations

Description: This topic is intended to explore a low cost approach for a Helmet Mounted Device (HMD) to improve pilot situational awareness (SA) in air-to-air and air-to-ground combat simulations and to support target cueing of sensors and weapons for High Off-Bore Sight (HOBS) applications. Helmet mounted sights (HMS) and displays are becoming essential equipment for today's war fighter. HMDs provide data needed for out-of-cockpit situation awareness, high angle of attack maneuvering, sensors and weapons cueing, and targeting. Although required for certain applications, the use of actual flight certified HMDs for virtual simulation is cost prohibitive for analysis and research organizations. Existing research-oriented HMDs are heavy and expensive. Monocular computer displays designed for "wearable" and mobile PCs, and commercial off-the-shelf (COTS) head mounted displays suited for the PC gaming industry, have limited field-of-view (FOV) and limited visual acuity at low (e.g. VGA 800 X 600 pixel, NTSC format) resolutions.

This effort is directed toward the research and development of a generic, flexible HMD/HMS system that satisfies the functional requirements of real-world systems, but better addresses the needs and constraints of use in the simulation and training environments. This requires leveraging rapidly emerging new micro-display technologies (such as Organic Light Emitting Diodes, Liquid Crystal On Silicon, Digital Light Processing, or miniature Liquid Crystal Displays) or novel exploitation of existing COTS HMDs through hardware or software modification to produce functional substitutes for the actual HMDs and HMSs. Consideration should be given to the data and/or imagery to be displayed (from total out-the-window imagery or limited head-up display (HUD), sensor, weapon, and targeting data, reticule, etc.). Applications in robust simulations of varying fidelity will require flexible configuration (high resolution, wide or narrow FOV, see-through or opaque, monocular or binocular, color or monochrome) depending on simulation output. Research should examine compatibility with available head tracking devices. Operation would require computer platform independence (i.e. run on Irix/Unix platforms such as Silicon Graphics Inc (SGI) systems and Windows/Linux PCs). Comparisons of functional capability of selected or resultant technology will be made with respect to actual flight hardware and will require demonstration using the Man-in-the-Loop Air-to-Air System Performance Evaluation Model (MIL-AASPEM) and the Fighter Requirements Evaluation Demonstrator (FRED). Development of a new HMD system is left as an option. The goal is to produce a low cost system (display with tracker and software) for minimal per unit cost (< $10,000.00/unit assembly).

Phase I: The effort in Phase I will include research of operational and functional HMD requirements and capabilities. In addition, a trade study between will be conducted, using cost as an independent variable, examining the impact on performance of HMD characteristics, including but no limited to: image source technology, resolution, field of view, see-through capability, optical design, head tracking quality, and display form. COTS components can be considered for incorporation into a concept if they are cost effective, address a particular design issue, and deliver the desired level of performance. The most promising two or three HMD concepts resulting from the trade study will be explored in greater detail through conceptual design and modeling

Phase II: This phase will start with the selection of a single concept from those explored in Phase I and the detailed design of a low-cost HMD based on the selected concept. A prototype system will be assembled to demonstrate the technology. Prototypes delivered to the Air Force will demonstrate their compatibility with PC and SGI platforms running MIL-AASPEM and/or FRED. A conceptual analysis of the life cycle cost improvements resulting from using emerging technologies should also be prepared.

Dual Use Commercialization Potential: Full scale development of Phase II product for integration with PC and SGI systems. Develop for use in DoD modeling and simulation, training, and mission rehearsal applications. Commercialization of resultant product will potentially benefit the entertainment and gaming industry, and military and civilian modeling, simulation, and 3D visualization, and training communities.

Related References

1. Barfield, W. and Caudell, T. (2000). Fundamentals of Wearable Computers and Augmented Reality. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

2. Milgram, P. and Colquhoun, H. (1999). Taxonomy of real and virtual world display integration. In Y. Ohta and H. Tamura (Eds.), Mixed Reality – Merging Real and Virtual Worlds. Ohmsha (Tokyo) and Springer-Verlag (Berlin).

KEYWORDS: Helmet mounted displays, Virtual reality, Head tracker, Flight simulation, Modeling, Simulation, MIL-AASPEM

AF03-043 TITLE: Simple 3-D Target Recognition and Identification

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

ACQUISITION PROGRAM: Aeronautical Systems Center (ASC)

Objective: The objective of this project is to enhance the operator's view of TV and Infrared sensor imaging systems from a 2 dimensional view to a 3-D view using attributes of hyperstereopsis.

Description: Increasing the standoff distance of the aircraft from ground targets has been an ongoing goal from the programs inception. The purpose of this SOTD effort is to provide target identification improvements using hyperstereopsis. Hyperstereopsis (enhanced 3-D imagery) is the result of fusing two images with larger than normal image disparities. Disparity is the well-known human sensory cue for depth perception (3D vision). Normal disparity comes from viewing an object at two different angles (approximately 2.4 inches interpupilary distance) resulting in 3-D (stereopsis) viewing from 0 to about 100ft. Past 100ft we rely on other 3-D cues similar to cues presented on any 2D screen. However, if we increase the interpuilary distance we create a hyperstereopsis effect, which enables us to view in, 3-D past 100 ft. The digital video images provided by the TV and Infrared systems on board the aircraft currently provide the necessary images for a hyperstereopsis utility. Thus we can exploit the human sensory capability using extremely large disparit images and cause a 3-D effect for viewing targets from extreme distances. The end result will enhance the sensor operator's capabilities to detect and recognize targets from extended standoff ranges.

Phase I: Determine the inter-sensor separations and ranges to target that provide optimum hyperstereopsis effects on target detection and identification. Provide a prototype software algorithm, which provides two spatially different views of the target from an existing aircraft digital video format. This should be an extremely low cost effort due to the fact that digital images and software algorithms already exists.

Phase II: Define the operator interface to view the two images (i.e. Deep Video Imaging, polarized goggles, split screen, helmet mounted display, TBD) and provide a working prototype device.

This phase would also: demonstrate the system capabilities to SBIR sponsor and war fighter personnel; define product development schedule and costs; describe potential dual use applications (i.e. search and rescue, etc).

Dual Use Commercialization Potential: Manufacture limited initial production of units (e.g. 2 units) for trial application in the aircraft simulator and for flight test. Demonstrate product capabilities during field trials and simulator assessments. Produce initial units for dual-use applications (i.e. search and rescue).

Related References:

1. AFSOC 356 Search for, Acquire, and Evaluate Objective Areas
2. AFSOC 227 Multidimensional Display
3. Howard, I.P. and Rodgers, B.J. (1995). Binocular Vision and Stereopsis. New York,NY: Oxford University Press.
4. Cumming, B. (2002). Stereopsis: Where Depth is Seen. Current Biology, 12, pp 93-95.
5. McSorley, E., and Findlay, J.M. (2001). Visual Search in Depth. Vision Research, 41, pp 3487-3496.
6. Blaser, E., and Domini, F. (2002). The Conjunction of Feature and Depth Information. Vision Research, 42, pp 273-279.
7. Roumes, C., Meehan, J.W., Plantier, J., and Menu, J-P (2001). Distance Estimation in 3-D Imaging Display. The International Journal of Aviation Psychology, 11, pp 381-396.
8. Cheung, K.M., and Milgram, P. (2000). Visual Detection with Hyperstereoscopic Video for Aerial Search and Rescue. Proceedings of the IEA 2000/HFES 2000 Congress, 3, pp 472-475.

KEYWORDS: Hyperstereopsis, Steropsis, Target detection and recognition

AF03-044 TITLE: Personnel Torso Thermo Cooler System

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Aeronautical Systems Center (ASC)

Objective: Provide a system to reduce the heat stress and cold weather exposure experienced by flight-line maintenance and aircrew personnel. The system needs to be compatible with mission environments and existing personnel equipment worn/used by flight-line maintainers and aircrew, to include NBC protective gear. With its dual heat-cool capability, the system should also provide medical triage hypothermia and hyperthermia mitigation to rescued personnel on combat search and rescue missions.

Description: The system proposed must be capable of operation (providing heat/cool capability) and personnel protection when operated in an NBC environment. The system must have the capability to remove a minimum of 700 BTU body heat per hour, and contain operator adjustable cooling variable rates between 700-1000 BTU heat per hour for a full two hours or more of continuous operation. Operation should be reversible in cold weather to provide personnel with localized heating. The system must be lightweight and not compromise body movement or interfere with performance of mission tasks. System power sources need to be compatible and operate with the intended mission environment and not affect operation of other flight line or aircraft systems, i.e. comply with electro-magnetic compatibility and interference (EMC/EMI) requirements. The system shall remain safe for personnel use and not be a shock hazard or source of ignition when used in explosive atmospheres. The system shall provide inherent controls, user alerts, and mechanisms to ensure safe operation. The proposed system needs to be individually configurable for use by aircrew and maintainers accommodating the majority male and female maintainer/aircrew population with a minimum number of sizes. The system needs to be self-powered, lightweight, resistant to chemical agents, corrosion resistant, easily decontaminated, (cleaned with common cleaning agent solutions and bactericides), easily maintained (use of common hand tools; use of no tools is highly desired), durable (at least 2000 failure free hours is also desirable), and reusable. The added capability to be powered by ground power cart or aircraft power to save self-contained battery/fuel cell charge for extended service interval is desired. There are products based on the Army PICS (Personal Ice Cooling System) and NASA's APECS (Aircrew Personal Environmental Cooling System) that provide cooling only, and rely upon availability of an ice or chilled water supply. Also being developed are systems based upon a refrigeration unit, such as the Army's PVCS (Portable Vapor-Compression Cooling System), which only provides cooling. Technologies that utilize a reversible compression cycle (i.e. heat pump), a peltier junction, or a combination of the two, are examples of those that may provide both heating and cooling.

Phase I: Conduct engineering design and system analysis to identify system and subsystem requirements. Provide conceptual design(s) and allocate requirements to system and subsystem components. System and subsystem requirements should consider, for example: operating temperature range, size, weight, temperature control range, material porosity, heat conduction, system and subsystem service life, battery or fuel cell operations capacity / life, flight-line and aircraft system compatibility to include power and electromagnetic compatibility / interference (EMI/EMC), reliability and maintainability. Describe commercial and other off-the-shelf products / technologies used in proposed designs and identify risk areas pertaining to high technical complexity or cost. Provide cost breakdown and estimates for proposed solutions and identify existing or potential dual-use applications.

Phase II: Provide prototype systems to assess requirement compliance through test and operational assessment. Identify any system shortfalls and changes needed to establish requirement compliance. Refine cost information to address any changes in proposed solutions.

Dual Use Commercialization Potential: This system and technology has potential in other commercial applications in industry and recreation. Potential users include firefighters, border patrol agents, off shore oil workers, construction workers, hunters, etc.

Related References:

1. http://www.sbccom.army.mil/products/cie/almcs.htm
2. http://www.sbccom.army.mil/products/cie/PVCS.htm

3. http://www.dfrc.nasa.gov/PAO/PressReleases/2000/00-30.html

KEYWORDS: Peltier Junction thermo cooler, Torso heat exchanger, Stored energy cell pack, Fuel cell energy cell compatible, Aircraft ground cart power compatibility, AFSOC helicopter electrical utility power compatible, EMC compatible, Electric shock resistance, NBC ensemble integrated, Flak vest compatible, Durability life testing, Common hand tool maintainable, Male and female torso compatible, Wireless intercom system compatible, PICS (Personal Ice Cooling System), APECS (Aircrew Personal Environmental Control System), Heat Pump

AF03-045 TITLE: Personal Computer (PC)-Based Aircraft Training System and Visualization Tool

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: To develop a personal computer (PC)/(laptop)-based training system incorporating an intelligent tutor for ground-based training and a Virtual Reality (VR) visualization tool. This system should support ground-based training in the Joint Primary Aircraft Training System (JPATS) with applicability to other Undergraduate Pilot Training (UPT) programs.

Description: Typically, training time available in the simulator and aircraft for initial pilot training is very limited. Specific training sorties in the aircraft or simulator are dedicated to such areas as landing patterns and communication procedures. However, these dedicated training sorties are often not frequent enough to quickly develop the skills needed for full competency. One of the most difficult flying training concepts to instruct and for the student to grasp in both the military and civilian sectors is the landing pattern. In the military, visual landings are accomplished from either a straight-in or overhead pattern, the overhead pattern being the most difficult. Overhead patterns are also used in many other military aircraft as a tactical maneuver to reduce exposure to enemy fire. Another difficult area to adequately train in the aircraft is radio procedures during traffic pattern events. Students are only exposed to “real-time” radio communication tasks during the actual sortie. Practicing radio procedures in an off-line interactive medium would better prepare the student for the actual sortie. A primary goal of this effort will be to explore the feasibility of using a PC-based training system to train landing patterns and radio procedures during traffic pattern operations. This research effort should investigate the use of two- and three-dimensional presentation (e.g., VR head mounted display) to facilitate student learning of the landing patterns. Using either the two-dimensional display or three-dimensional VR display, students can follow through a pattern flown by an “expert” and then practice themselves. Voice recognition and speech generation tools should also be explored to give the student an interactive medium for learning proper radio procedures used during landing patterns and other traffic pattern procedures. An intelligent tutor would help tailor the training to the needs of the student as he/she progresses through the training. Some of the benefits of this type of training system are the student’s ability to repeatedly practice these complex skills, the ability to replay the student’s performance so the student can observe his/her performance, and the adaptiveness of the training to meet the student’s specific needs.

Phase I: Phase I will result in a training requirements analysis of critical JPATS training and rehearsal needs focused on landing patterns and communication procedures. Results from Phase I should also provide the specification of minimum requirements for the PC-based training system and a survey of off-the-shelf technologies that might be incorporated into the solution. In addition, the Phase I effort will demonstrate a PC-based proof-of-concept technology to train a typical normal overhead pattern in the JPATS aircraft. The system will incorporate PC-compatible stick, throttle, and rudder pedals and a two- or three-dimensional display to present the basic concept of the training system to support JPATS ground-based training with a PC.

Phase II: Phase II will build upon Phase I to fully develop, refine, test and evaluate the PC/laptop-based training system including the integration of voice recognition software, speech generated feedback, intelligent tutor adaptive capabilities, and proof-of-concept training scenarios for radio procedures during traffic pattern operations.

Dual Use Commercialization Potential: This effort will provide a uniquely capable and cost-effective, portable high fidelity, interactive ground-based training system for JPATS. The results of this effort should have high value for commercialization as a commercial flight training tool. Although commercial flight does not include the 360 degree overhead pattern, it does incorporate a "rectangular pattern" with similar training challenges and complexity. Situational awareness in the pattern is typically difficult to instruct in both the civil and military system. Additionally the system can be used to train pilots in the commercial sector (and almost every other military aircraft system) to avoid "Controlled Flight Into Terrain" (CFIT). CFIT has become a high interest item due to a number of commercial aircraft CFIT accidents. Additionally, the system can be used to train pilots on "strange field" procedures so they would be familiar with airfields with high accident potential before they actually fly to that particular airfield. Dual Use potential is significant as no other deployable, low-cost technology exists that provides a common architecture and approach for an intelligent tutor for ground-based training for commercial flight training system to instruct difficult flight skills.

Related References:
1. Andrews, D. H., et al. (1995). Potential modeling and simulation contributions to Air Education and Training Command flying training: Specialized Undergraduate Pilot Training (AL/HR-TR-1995-0157). Mesa, AZ: Armstrong Laboratory, Aircrew Training Research Division.

2. Burgeson, J.C., et al., (1996). Natural effects in military models and simulations: Part III – Analysis of requirements versus capabilities. Report No., STC-TR-2970, PL-TR-96-2039, (AD-A317 289), 48 p., Aug.

3. Kleiss, J. A. (1995). Visual scene properties relevant for simulating low-altitude flight: A multidimensional scaling approach. Human Factors, 37(4), 711-734.

4. Mattoon, J. S. (1994). Designing instructional simulations: Effects of instructional control and type of training task on developing display-interpretation skills. The International Journal of Aviation Psychology, 4(3), 189-209.

5. Thurman, R. A., & Mattoon, J. S. (1994). Virtual reality: Toward fundamental improvements in simulation-based training. Educational Technology, 34(8), 56-64.

KEYWORDS: Ground-based training system, Radio procedures trainer, Intelligent instructional systems, Flight visualization, Flight training, Desktop flight training

AF03-046 TITLE: <u>A New Display Paradigm for Air Traffic Control Management</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: Apply near-to-eye display technology to air traffic control management to accurately register aircraft on the runway and its surroundings to improve ground safety

Description: The need exists to develop a near-to-eye or head-mounted display for air traffic controllers that allows a continuous head-up, out-the window view of the runway and eliminates the time-consuming scanning, eye re-accommodation, and cognitive integration required in accessing this same data on their current head-down displays. The use of a near-to eye head-mounted display allows the "scene-linking" of imagery, e.g., cueing the presence of aircraft and highlighting the location of runways, to improve ground safety. These safety benefits are expected to be significant in low visibility conditions, in which scene-linked imagery may highlight the location of planes that the controller may not be able to see directly. Near-to-eye display technology provides the hardware elements, which must accurately register the controller's view with the location of the aircraft on the runway. This display must have a comfortable form factor and would look and act like conventional eyewear, such as eyeglasses, to encourage consumer adoption. These features promise applications in airports, military and commercial aircraft systems, and navigation and targeting for Special Operations Forces and the Army by providing imagery through all weather conditions and all illuminations.

Phase I: Phase I activity shall include (1) a study of the air traffic control task and the development of a suitable concept of operation for the integration of a head-mounted display, (2) an analysis of the minimum field of view and resolution required to improve the air traffic control task, and the potential need for head tracking, (3) a design for a see-through head-mounted display system capable of sufficient resolution and field of view, and (4) several socially acceptable form factors, e.g., an eyeglass configuration, as potential candidates for selection of a display configuration appropriate for air traffic control.

Phase II: Phase II activity shall be primarily directed toward the construction of a prototype for limited operational testing. Effort shall address (1) system integration with air traffic control components and software, and (2) real-time update of imagery in dynamic environments, e.g., as the operator monitors the visual separation of approaching planes and controls the taxiing of aircraft along the runway. Several prototypes may be required to examine all display forms identified in Phase I.

Dual Use Commercialization Potential: These display technologies may be used in a broad range of military and civilian pervasive computing applications, e.g., for special operation teams or firefighters operating in "smoke-filled" environments with potential applications in military and commercial airports and airlines.

Related References:
1. Barfield, W. and Caudell, T. (2000). Fundamentals of Wearable Computers and Augmented Reality. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

2. Fadden, S., Ververs, P., & Wickens, C.D. (1998). Costs and benefits of head-up display use: A meta-analytic approach. Proceedings of the 42nd Annual Meeting of the Human Factors & Ergonomics Society. Santa Monica, CA: Human Factors Society.

3. Merlo, J.L., Wickens, C.D., & Yeh, M. (1999). Effect of reliability on cue effectiveness and display signaling. (Technical Report ARL-99-4/FED-LAB-99-3). Savoy, IL: University of Illinois, Aviation Res. Lab.

4. Milgram, P. and Colquhoun, H. (1999). A taxonomy of real and virtual world display integration. In Y. Ohta and H. Tamura (Eds.), Mixed Reality – Merging Real and Virtual Worlds. Ohmsha (Tokyo) and Springer-Verlag (Berlin).

5. Yeh, M. and Wickens, C.D. (2001). Display Signaling in Augmented Reality: The Effects of Cue Reliability and Image Realism on Attention Allocation and Trust Calibration. Human Factors. In press.

KEYWORDS: augmented reality, wearable displays, head tracking, near-to-eye display technology, air traffic control, head-mounted display, HMD

AF03-047 TITLE: Integrated Cognitive Architectures for the Joint Synthetic Battlespace

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Electronic Systems Center (ESC)

Objective: Develop cognitively based synthetic force modeling tools to rapidly model intelligent agents in novel combat scenarios.

Description: The Joint Synthetic Battlespace (JSB) provides an approach to Simulation Based Acquisition (SBA) of weapon systems throughout all phases of the acquisition cycle. The JSB will incorporate a wide range of simulation capabilities based on physical processes rather than stochastic simplifications. One of the greatest challenges facing JSB users is the lack of cognitively based synthetic force models for future potential classes of missions. Today, the knowledge that is used in most cognitive models is derived from tasks lists, which are then customized by expert opinion. That is, when creating a model the developer decides on a scenario and then reviews the lists of tasks that a combatant would perform in that situation. These tasks delineate the types of procedural and domain knowledge that a model must embody to generate combatant behavior. A problem arises when the type of warfare being contemplated is new. For example, the space of potential military missions is evolving to include activities such as information operations, integrated effects-based operations, asymmetric warfare, and humanitarian relief (as a primary role, rather than a secondary activity). In addition, the military is developing revolutionary capabilities such as directed energy weapons that incapacitate, rather that kill. One of the goals of the JSB is to provide an environment consisting of constructive, virtual, and human-in-the-loop (HIL) simulations in which to test out future warfare concepts. Yet, there are no tasks lists describing how such missions will be undertaken; nor are there experts who have built up knowledge on the conduct of such operations. This presents a serious challenge to model builders. We need new cognitive modeling generation techniques that go beyond the task list approach and that can handle realistic but envisioned future operational scenarios. We need new ways to produce suitable procedural and domain knowledge specifications to model an intelligent combatant at multiple levels of abstraction. Furthermore, we need tools to rapidly convert these knowledge-based specifications into intelligent (flexible and adaptable behavior) operational models of combatants as individual agents and working teams for deployment in a JSB environment. With this SBIR topic, the government is soliciting new approaches for producing a model development toolkit to define the cognitive task knowledge (both procedural and declarative) representation needed for future potential combat scenarios. The government is looking for model specification and development methods that provide significant flexibility and adaptive capability to minimize the effort required to set up individual representations of constructive entities at run-time.

Phase I: The Contractor will develop and demonstrate their new approach to defining task knowledge for future combat scenarios. To the maximum extent possible, the approach should make use of and extend traditional knowledge elicitation and representation techniques.

Phase II: The Contractor shall design, construct and demonstrate a prototype cognitively based synthetic force models using the knowledge elicitation methods developed in phase I. The Contractor shall demonstrate the model in a JSB experiment. The Contractor shall also detail the plan for Phase III development and commercialization efforts.

Dual Use Commercialization Potential: The methodology to develop cognitive models of human behavior has potential application in many arenas requiring constructive representation of behavior, including air traffic control system development, transportation system analysis, etc. Constructive simulation can also support direct training applications and decision aid development. There is also significant opportunity in the gaming industry where the trend is for the development of more complex and realistic human behavior models for computer generated forces.

Related References:

1. Schraagen, J.M, Chipman, S.F. & Shalin, V.L. (2000). Cognitive Task Analysis. Mahwah, NJ: Lawrence Erlbaum Associates.

2. Pew, Richard W., and Mavor, Anne S. (1998). “Modeling Human and Organizational Behavior: Application to Military Simulations”, National Academy Press.

3. Mulgund, S.S., Harper, K.A., Zacharias, G.L. and Menke, T. (2000). “SAMPLE: Situation Awareness Model for Pilot-in-the-Loop Evaluation”, Proceedings of the 9th Conference on Computer Generated Forces and Behavior Representation. Orlando, FL.

4. Anderson, J. R., Lebiere, C., Lovett, M. C., & Reder, L. M. (1998). ACT-R: A higher-level account of processing capacity. Commentary in Behavioral and Brain Sciences, (21), pp. 831-832.

5. Jones, R.M. Laird, J. E., Nielsen, P. E., Coulter, K. J., Kenny, P., & Koss, F. V. (1999). Automated Intelligent Pilots for Combat Flight Simulation. AI Magazine. Spring, 1999.

KEYWORDS: Joint Synthetic Battlespace, Human Behavior Representation, Constructive simulation, Cognitive modeling, Cognitive engineering, Simulation-based acquisition

AF03-049 TITLE: Wireless HMD data transmittance

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop wireless communication system for all video, helmet tracker and control signals between a Helmet Mounted Display/Tracker system and its host aircraft.

Description: Design, build, demonstrate and test a prototype system that would provide a wireless data interconnect between a Helmet Mounted Display/Tracker system and an aircraft.

Current technology requires that a pilot wearing a Helmet Mounted Display/Tracker be connected to the aircraft with a cable. The cable transfers control information, tracking data, and display data between the aircraft and the helmet. The design of this cable is complex, costly, and can decrease system reliability. Additionally, multiple power conductors are required. The entire cable system must incorporate a reliable and safe quick disconnect type of connector that permits automatic separation during ejection or emergency ground egress. Many of these ‘problems’ can be alleviated by using wireless transmission for all of the video, tracker and control signals. This will significantly reduce or eliminate the requirements of the interconnect cable/connector reducing system complexity, and cost, and enhance system safety.

This system must support multiple bi-directional video/stroke symbology feeds, high-speed helmet tracker data, and control signals. There will be a maximum of three color (NTSC) display signals from the aircraft to the helmet display(s). There is one color (NTSC) camera video from the helmet to the aircraft. Tracker data consists of three 4.5 MBit/S digital streams. There are several digital control signals as well.

Other considerations:
· Transmission distance and envelope required depends on system design and transmitter/receiver placement in cockpit. It is anticipated that a maximum of 4 feet will be required.
· There needs to be a 4pi sterradian coverage.
· System must operate in existing EMI/EMC environment, not cause EMI problems to aircraft.
· System should not be capable of being intercepted/exploited.
· Head mounted equipment must be small, light weight and meet head/helmet inertial properties.
· Ideally, power for this system would be self contained on the helmet (i.e. battery operated) but final solution may dictate that power supply to the helmet system be retained via cable/connector.
· A bit error detection and correction scheme must be part of the system.
· The final system must be human safe and able to withstand the rigors of fighter/bomber aircraft flight regimes including high-G maneuvering, emergency ground egress and ejection.
· System should support growth to higher resolution displays/imagers.

Phase I: Analyze current technology and conduct a feasibility study for a system to meet requirements. Prepare top level conceptual design. Submit report.

Phase II: Implement and demonstrate a prototype system as designed in Phase I with consideration of flight safety requirements. Submit report.

Dual Use Commercialization Potential: This capability can be used in any application where man mounted systems must pass data to an external system where an umbilical connection would hamper movement or cause safety issues. Such applications could include firefighters, and other rescue persons, divers, racecar drivers, athletes, foot soldiers, doctors in operating rooms, etc.; however, the system must still meet all requirements for military aircraft environment.

Related References:

1. IEEE 802.11b

2. Bluetooth specification

3. IEEE 1394B

4. MIL-H-87174 (USAF) 25 October 1983

5. MIL-STD-461D 11 January 1993, Control of Electromagnetic Interference Emissions and Susceptibility

6. MIL-STD-462D 11 January 1993, Measurement of Electromagnetic Interference Characteristics

KEYWORDS: Helmet Mounted Systems, Wireless, Helmet Mounted Trackers, Helmet Mounted Displays

AF03-050 TITLE: Displaying Tailored Real-time Information in Multi-Crew Cockpits

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Improve the ability of the warfighter in the cockpit to find, identify, and attack mobile and concealed targets in all weather conditions. Develop an innovative approach to integrate advanced operator-vehicle interface (OVI) technologies (e.g., graphical user interfaces, large electronic displays, speech recognition) so crewmembers can manage and integrate off-board data to achieve mission objectives. This R&D effort will contribute to future joint and service-unique warfighting needs in data visualization and situational understanding, aural and visual interface, intelligent aiding, and decision support.

Description: Optimally present data to multiple users with different perspectives (e.g., the crewmembers in the cockpit). In multi-person work environments each crewmembers' tasks and responsibilities often require that they have information that is both 1) specifically tailored to support their unique mission role and 2) coordinated with the information presented to other crewmembers. For example, while one crewmember is identifying threats and developing strategies for avoiding them, another may be finalizing strategies for weapon delivery. Both of these activities often have an effect on the aircraft's route of flight, with the overall goal of developing a flight plan that simultaneously optimizes threat avoidance and weapon delivery. It is very difficult to generate this individualized-collaborative perspective of the "environment," or the "battlespace." The creative challenge is to design meaningful ways to display information from multiple sources - whether from outside or inside the aircraft - that are not only tailored to the needs of each individual crewmember, but retain a degree of commonality that permits efficient crewmember coordination and information sharing; a "data fusion/collaboration" capability. An effective solution will improve crew situation awareness, increase mission effectiveness, and reduce crew workload.

Phase I: Develop a feasibility concept that will identify a specific cockpit application, subject matter experts, and a baseline system to which new ideas will be compared, and will develop a preliminary concept with specific examples of an OVI that supports data fusion and collaboration among the individual members of a multi-crew cockpit. This initial "paper-and-pencil" design must provide specific examples of proposed innovative display concepts.

Phase II: Phase II activities will focus on software development and culminate in the demonstration of a prototype that operationalizes the OVI concepts defined during Phase I. The OVI concepts should improve crew situation awareness, reduce workload, and enhance mission effectiveness. Further, the Phase II prototype should demonstrate substantial commercialization potential.

Dual Use Commercialization Potential: Application to a USAF system and installation and testing at a USAF test cite will occur during Phase III. Commercial applications of these collaborative display and information sharing technologies are vast. Any system with multiple crewmembers having diverse responsibilities, but required to share information can benefit from this technology. All the military services operate multi-crew aircraft and much work already is underway regarding shipboard and command post application. It is expected that this SBIR will be able to exploit some of this research (see references). There are several potential non-military applications. Some examples include air traffic control, civil emergency/disaster command centers, and complex industrial process monitoring.

Related References:

1. Brown, S. M., & Finegold, L. S. (1999). Multi-sensory command and control advanced technologies (MCCAT) for information operations (IO) applications. Advanced development program advocacy briefing to AFRL/HE.

2. Goodwon, E. H., Moore, W., Turner, D., Fayette, D., McQuay, W., Trumble, K., Welch, M., & Gruly, T. (1999). All-weather prosecution of time critical targets: Midterm TCT kill-chain capability enhancement plan.

3. Hall, D. L. (January, 1997). An introduction to multisensor data fusion. Proceedings of IEEE, 85, 13).

4. Liggett, K. K. (2000) Tactical Information Dominance (TACID). Program advocacy briefing.

KEYWORDS: Situational Awareness, Real-Time Information, RTIC, Data Fusion, Information Fusion

AF03-051 TITLE: Variable Transmittance HMD Visor

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop technologies enabling the manufacture and fielding of an affordable, customizable (trim to fit), variable transmittance helmet visor that adds no secondary reflections.

Description: With the advent of Helmet-Mounted Displays (HMDs), the pilot no longer has the option of raising the visor when transitioning from high to low light level conditions; therefore, a variable-transmittance visor is required. Previous SBIR efforts have developed continuously variable transmissivity visors using liquid-crystal shutter technology and visors consisting of relatively thick base/cap pairs. This approach increases the cost, adds distracting secondary reflections, and complicates manufacture and customizing/trimming the visor’s fit to prevent light leakage. A simpler, low-cost approach to providing this variable transmissivity capability that will allow the visor to be customized (trimmed) for individual pilots and add no secondary reflections is required. The technology must also be spectrally neutral and be compatible with polycarbonate helmet visors.

Phase I: Identify material technologies that could provide for a low-cost, customizable, variable transmittance visor. Determine drive electronics requirements . Identify program’s high-risk areas. Since the visor might be an optical element in an HMD, its internal reflective qualities must be suitable for use as an optical surface in an HMD system.

Phase II: Down select the most promising technologies and develop into a prototype demonstration including associated drive electronics.

Dual Use Commercialization Potential: Low-cost, variable transmittance technology could also have civilian sector applications in the areas of space suit visors, race helmets, welding, eyewear, windows, aircraft/spacecraft windows, automobile sunroofs, non-emissive displays

Related References:

1. Kosa, T., Palffy-Muhoray, P., Taheri, B., & Post, D. L. (1998). Ambient light control using guest-host liquid crystal dye systems. (Report No. AFRL-HE-WP-SR-1998-0002). Wright-Patterson AFB, OH: Air Force Research Laboratory.

2. Taheri, B., Palffy-Muhoray, P., Kosa, T., & Post, D. L. (2000). Technology for electronically varying helmet-visor tint. In R. J. Lewandowski, W. Stephens, L. A. Haworth, & H. J. Girolamo (Eds.), Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE): Head-Mounted Displays V, 4021, 114-119.

KEYWORDS: helmet-mounted display, HMD, tint, shutter, visor, variable transmittance, electro-optical, customized trimming, ambient light, illumination, illuminance

AF03-052 TITLE: Intelligent Scenario Generation Tools for Training and Rehearsal

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Develop intelligent software tools to automatically generate training scenarios to meet syllabus requirements and target the development of student skills and competencies identified as weak, deficient, or in need of refresher training.

Description: This effort will develop software tools that will interface with training management databases to extract student historical data, develop scenarios to target the deficient mission essential competencies and skills and then interface with simulation control stations/instructor operator stations for scenario design to target student deficiencies. As part of this effort, expert judgments and experience with diagnosing complex skill performance and deficits will be delineated and modeled using cognitive task analysis methods. The resulting "expert diagnostician" model will be embedded in software that can assist scenario developers in determining the appropriate content and sequence of training and rehearsal scenarios for enhanced learning and performance. The tools are envisioned to be versatile and adaptive to meet the training simulation needs of both individual students and teams operating in both local or distributed training environments. The work to be accomplished in this effort directly supports a critical need. Specifically, intelligent scenario generation tools as key enabling training technologies that require maturation and development for use in the program.

Phase I: Phase I will assess the feasibility of an automated scenario generation capability concept by performing various analysis tasks. Research in this phase will identify components of expert instructor pilot expertise that are relevant to the diagnosis of student performance and areas of competency and skill need. Phase I will also identify components of student performance data and syllabus information and develop a prototype database of student training profiles and performance data that will serve as the basis for determining scenario selection. Research in this phase will also identify critical trigger events of various missions and engagements and the instructional strategies and scenario structure needed to develop requisite knowledge, skills, and abilities for the successful accomplishment of the mission. Finally, Phase I will conduct a detailed analysis of existing training simulation scenario development and control stations to identify interface requirements for the scenario generation tools to input or modify scenario setup information.

Phase II: Phase II will develop and demonstrate prototype software to diagnose air combat competency and skill deficiencies. It will also develop methods to extract student or trainee performance data from the prototype database, diagnose the deficient skills or competencies using the expert instructor pilot cognitive model, and then apply the expert model to match deficiencies with training scenario characteristics with critical events of missions or engagements to target the deficient skills or competencies. From this match, the software will create sets of various scenarios that could be used to train individuals or an entire four-ship team. The software will need to generate sample scenario set-up information suitable for use in current Air Force air-to-air Distributed Mission Training suites. The demonstration will provide data on the efficacy of the diagnostic tools for appropriateness of scenario generation to impact deficient competency and skill areas for the prototype subject area.

Dual Use Commercialization Potential: Military simulation training systems being fielded in the United States and other countries for current and emerging weapon systems can use these scenario generation tools to dramatically enhance the effectiveness and reduce costs of simulation training. Automated, tailorable scenario generation tools were identified as a key enabling training technology that requires maturation and development. With the proliferation of simulation training in the commercial world, these same intelligent diagnostic tools for creating deficiency-targeted simulation training scenarios will be useful for civilian training programs that use simulation as critical training mediums such as aviation or nautical training.

Related References:

1. Burgeson, J.C., et al., (1996). Natural effects in military models and simulations: Part III – Analysis of requirements versus capabilities. Report No., STC-TR-2970, PL-TR-96-2039, (AD-A317 289), 48 p., Aug.

2. Crane, P. Designing Training Scenarios for Distributed Mission Training. Presented at: 10th International Symposium on Aviation Psychology, Columbus, OH, April 1999.

3. Crane, P., Robbins, R., Bennett, Jr., W. and Bell, H. H. (2001). Mission Complexity Scoring for Distributed Mission Training. In, Proceedings of 2001 Industry/Interservice Training Systems Conference, Orlando, FL: National Security Industrial Association.

4. Joint Strike Fighter Program Office Homepage: http://www.jast.mil.

5. Defense Modeling and Simulation Office homepage: www.dmso.mil

KEYWORDS: Air Combat tactics training and rehearsal, Distributed mission training, Intelligent training systems, Performance diagnosis and measurement, Scenario development

AF03-053 TITLE: Time Critical Targeting Training and Rehearsal Environment

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: To develop a high fidelity time critical targeting (TCT) decision-making and training environment

Description: This effort will develop a high fidelity and deployable distributed time critical targeting decision-making training and rehearsal environment for the Joint Strike Fighter (JSF). One of the most difficult activities associated with air combat today and in the future is related to the decision process and evaluation of alternative courses of action required for time critical targeting. Lessons learned from Desert Storm and Kosovo point to the fact that many of our adversary's assets where able to move to new locations almost immediately after they had been used, while the Coalition decision making process in some cases took 6-8 hours to complete. Even with dynamic retasking of air assets, the decision process still took long enough to preclude Coalition forces from successfully engaging and destroying adversary assets. Although the timeline for time critical decision-making in Kosovo was dramatically reduced, the Chief of Staff of the Air Force has continuously reiterated the need for a TCT analysis and decision-making process that occurs "in minutes, not hours." Moreover, TCT-type activities do not represent the "routine" weapons employment modes for current or next generation air combat systems such as the A10, F15 E, F16 and Joint Strike Fighter (JSF) respectively. The infrequent, but extremely important nature of TCT makes it one of the central training and rehearsal targets of need for near-term and future warfighting. This effort will develop an embedded toolset and supporting visualization capabilities that permit combat crews to practice analysis and decision-making for time critical targeting situations. This effort will also develop a unique and computer-based, high fidelity and instructionally principled simulation environment to facilitate the development and maintenance of TCT mission essential competencies (MECs).

Phase I: Phase I will result in a proof-of-concept TCT analysis and decision-making toolset and visualization capability for TCT-related missions. In addition, the Phase I effort will preliminary specifications and an exemplar technology to support high fidelity TCT training and rehearsal.

Phase II: Phase II will build upon Phase I to fully develop, refine and evaluate the decision making toolset and visualization capabilities and evaluate the toolset and visualization capabilities for reducing the time required for TCT analysis of alternatives and decision-making. Phase II will also demonstrate a high fidelity and instructionally principled virtual and constructive prototype simulation environment for training and rehearsing TCT. Phase II will also conduct training effectiveness and mission readiness evaluations using the prototype and demonstrate training transfer to actual decision-making and TCT exercises or events.

Dual Use Commercialization Potential: This effort will provide a uniquely capable and cost-effective toolset for complex decision analysis and visualization that does not exist today but which is of considerable utility to other Military and civilian agencies that must respond rapidly to dynamic situations and crises. Moreover, a deployable high fidelity, interactive TCT training and rehearsal capability has considerable value for commercialization as TCT represents a complex and difficult activity that will challenge the state-of the art in instructional design, modeling and simulation. Since TCT competencies are represented in many non-military forms such as civil defense rapid response teams, hazardous materials teams and crisis action planners, dual use potential is significant. There is currently no other technology exists that provides a common architecture, models and approach to this type of complex decision-making, visualization and training and rehearsal.

Related References:

1. Burgeson, J.C., et al., (1996). Natural effects in military models and simulations: Part III – Analysis of requirements versus capabilities. Report No., STC-TR-2970, PL-TR-96-2039, (AD-A317 289), 48 p., Aug.
2. Distributed interactive simulation systems for simulation and training in the aerospace environment. Proceedings of the Conference, Orlando, Fl, Apr 19-20, 1995. Clarke, T. L., Ed. Society of Photo-Optical Instrumentation Engineers (Critical Reviews of Optical Science and Technology, vol. CR 58) 338p.
3. Fowlkes, J. E., Lane, N. E., Salas, E., Franz, T., & Oser, R. (1994). Improving the measurement of team performance: The TARGETS methodology. Military Psychology, 6, 47-63.
4. Guzzo, R. A., & Salas, E. (1995). Team effectiveness and decisionmaking in organizations. San Francisco: Jossey Bass.
5. Kraiger, K., Ford, J.K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. Journal of Applied Psychology, 78, 311-328.
6. Salas, E., Bowers, C. A., & Cannon-Bowers, J. A. (1995). Team processes, training, and performance. Military Psychology, 7, 53-139.
7. Shute, V.J. (1995). SMART: Student Modeling Approach for Responsive Tutoring. To appear in a special issue of User Modeling and User-Adapted Interaction: An International Journal, 5, 1-44.
8. Tambe, M., & Rosenbloom, P.S. (1995). Agent tracking in real-time dynamic environments: A summary and results. In M. Woodridge, K. Fischer, P. Gmytrasiewicz, N. Jennings, J.P. Muller, & M. Tambe (Eds.), Working notes of the IJCAI-95 workshop in agent theories, architectures, and languages (pp. 173-189), Montreal, Canada.

KEYWORDS: Air Combat tactics training and rehearsal, Distributed mission training, Distributed mission operations, Dynamic aerospace control, Dynamic decision-making, Team integration and decision making, Performance measurement, Time critical targeting

AF03-054 TITLE: <u>Body Worn Graphic Image Generator for Simulator Based Training</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Development of a body worn/deployable graphic image generator for simulator-based training that must provide greater than 5000 x 4000 pixel resolution for recognizing objects at realistic ranges and image update rates to support fast-moving vehicular training platforms. This represents an order-of-magnitude increase in performance over what is considered high-resolution image generation technology. These image generators are large stationary devices that are difficult to deploy and operate. At a minimum, to produce high-quality dynamic images, the body worn/deployable image generator should update at 60 HZ, noninterlaced. Imagery will be displayed on state-of-the-art ultra high resolution head-mounted displays currently in development by the Air Force.

Description: The Air Force is developing deployable/head-mounted displays with an order-of-magnitude increase in resolution over current commercial technology. This is necessary to present out-the-window and sensor imagery for training applications with 20/20 resolution a pilot would see in the real world. The Air Force wishes to capitalize on rapidly advancing commodity graphics technologies and is seeking a body worn/deployable image generator to affordably generate imagery for these new advanced deployable displays with the resolution and interfaces required. The focus of this solicitation is to support the development of a reliable, high performance, body worn graphic image generator system, including hardware and software that produce resolution, frame-rates, and scene complexity required for realistic air-to-air and air-to-ground training in a fast-moving Joint Strike Fighter (JSF) deployable visual system. This system must include panorama night vision goggle simulation for night combat operations and daytime out-the-window visual scenes.

Phase I: Provide a technical report documenting the feasibility of the concept and provide a feasibility demonstration.

Phase II: Phase II will result in prototyping, demonstrating, and testing the concept proposed under Phase I and a technical report.

Dual Use Commercialization Potential: This work, combined with ongoing Air Force efforts to increase image resolution, would substantially benefit the ever expanding worlds of virtual reality for industrial design (i.e. automotive, and boat manufacturing), medical technology, special effects applications in the electronic media, and commercial video game and computing hardware and software. Other Military applications requiring this technology include infantry and force protection Distributed Mission Training (DMT) applications.

Related References:
1. Niall, K.K. & Pierce, B.J. (2000). Assessment of visual requirements, in Aircrew Training: Methods, Technologies, and Assessments. Mahwah NJ: Lawrence Erlbaum Associates, Inc.

2. Wight, D., Best, L., & Peppler, P., (1999). M2DART visual display, A real image simulator display system, in Proceedings of Aerosense Conf., Orlando, FL.

3. Peppler, P. & Stephens, S. (1999). Visual systems for distributed mission training. Communications of the ACM, 42 (9).

4. Spaulding, B., & Peppler, P., (1999). A PC-based image generator for flight simulation. In Proceedings of the Advanced Simulation and Training Conf., San Diego, CA.

5. Pierce, B.J., Geri, G.A. & Hitt, J. (1998). Display collimation and the perceived size of flight simulator imagery (AFRL-TP-1998-0058, AD A359409). Mesa, AZ: Air Force Research Laboratory, Warfighter Training Research Division.

KEYWORDS: Body Worn, Simulator, Graphics, Visualization, High-Resolution, Image Generator, Graphic Generator, Portable, Simulator Based Training, Training, Head-Mounted, Eye Glasses

AF03-055 TITLE: Deployment Survivability for Mobile Ground Stations

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Human Systems

ACQUISITION PROGRAM: Space (SP)

Objective: Development of deployment region specific protection information and training technology to support pre-deployment and field reach-back capabilities

Description: Advance deployment teams, special operations units, and mobile space forces face a variety of potential threats responding to 'rapid deployment challenges' across the globe. In the fluid and multi-polar contemporary geopolitical environment, Nuclear-Biological-Chemical-Environmental threat assessment and response profiles have become essential to the conduct of strategic and tactical policy. Survivability is an important component in preserving maximal impact of US force projection capabilities abroad. Effective posture in regards the awareness, detection, and response to a range of deployment threats in a myriad of potential environments has become an integral component of a successful force protection and survivability program, particularly for advance deployment special operations units and mobile space forces. The development of distributed simulation technology focuses on biological and environmental threats that mobile forces must address. Survivability additionally entails force-internal threats that can affect force performance, cohesion and projection of mission capability. Considerations for developing the ongoing deployment support include both rapid time-frame pre deployment briefing and field reach back capabilities to access dynamic interactive information and simulation on: 1) deployment settings, 2) geography, climate, 3) regional peoples and cultures, 3) risks specific to the environment including natural threats as regards water, food, geology, terrain, weather and exposure patterns, local flora and fauna, as well as 4) regional endemic and emerging diseases that US forces might confront and select countermeasures and their recommended implementation. Force deployment protection and survivability measures for this project are viewed both in terms of enhanced recognition and identification of emerging or active threats, and also in terms of understanding, selecting, and implementing a range of threat-specific countermeasures either on a pre-emptive or reactive fashion.

Phase I: Develop preliminary biological and environmental threat modules as a prototype for wider force protection and survivability information and training technology. Create an architecture to support comprehensive training and operational materials for threat and force protection-centered deployment. As international threat assessments change, rapid authoring of new and modified scenarios can be dynamically tailored to provide pre-deployment training and provide rapidly updated information through reach back capabilities once forces are deployed in the field. Demonstrate capability on a cross-training deployable technology.

Phase II: Develop a formidable range of biological and environmental threats specific to the deployment region. Assess trainee recognition and response requirements regarding preparedness, situational awareness, and to individual and group level dynamic problem solving. Evaluate trainee performance to application of limited deployment scenarios. Develop, apply and validate high-fidelity training content modules across operational contexts in a distributed fashion.

Dual Use Commercialization Potential: Address multiple applications requirements throughout the defense and intelligent community. In addition, commercial development would open sizable markets in supporting a variety of users: first responder organizations responsible for bomb threat and terrorism defense; CDC, USAMRIID, NATO, and UN agencies responding to endogenous and emerging infectious disease crisis; HAZMAT and environmental event responder teams; and, a range of biomedical, laboratory, and industry decontamination responders.

Related References:
1. L. Pryor & G. Collins. (1996). Planning for contingencies: a decision based approach, Journal of Artificial Intelligence Research, 4:287-339.

2. J.E.Russo, V.H. Medvec, & M.G. Meloy. (1996). The distortion of information during decisions, Organizational Behavior and Human Decision Processes, V.66#1, p.102-110, April.

3. J.W. Payne, J.R. Bettman, & E.J. Johnson. (1997). The adaptive decision maker: Effort and accuracy in choice, in Research on Judgement and Decision Making, W. Goldstein & R. Hogarth, Eds., Cambridge University Press, p. 454-481.

4. Joint National Training Capability (2002). United States Joint Forces Command, Norfolk, Va. March.

KEYWORDS: Force Protection Training, Bio-defense, Deployment Environments, Environmental Threats, Biological Threats, Situational Awareness

AF03-056 TITLE: Messaging System Simulation for Space Operations

TECHNOLOGY AREAS: Information Systems, Space Platforms, Human Systems

ACQUISITION PROGRAM: Space (SP)

Objective: To research and develop an intelligent simulation training environment to support the instructor and student interaction of a subscriber terminal.

Description: Advances in the understanding and application of student and instructor interaction has made rapid progress due to the technological changes in education and training. However, these advances have not been applied to the majority of space system training and education, nor have these advances been explored for potential application to space training. Currently, there is a desperate need for innovative applications from research to apply to space programs that would facilitate the student and instructor interaction of subscriber terminals without intervention into the operational environment. A simulation capability is needed to replicate the operational unit messaging system. The need for training is apparent in the deficiency of operator capability to interpret data and send an operational status message to all within the network. The intelligent simulation approach should allow space operators a high fidelity, mission-oriented training capability to enable instructor and students to communicate via terminals through an unclassified path on the current subscriber terminal. In addition, the tool should allow the user to send a scenario of low speed data and send and receive plain text messages. This capability should enhance student abilities to understand the operational messaging system through simulation training and develop efficient and accurate instant message capabilities for information dispersion to an individual with a specific need or for all participants within a space network. An ultimate proof-of-concept simulation technology capability will be developed based on demonstration assessment.

Phase I: Demonstrate the feasibility to develop an application-based simulation training technology to support the instructor and student interaction and messaging required for operation checklist training. Training technology demonstration and CONOPS assessment should be used to support the training capability.

Phase II: Develop and demonstrate a prototype messaging simulation technology to support and assist the training of students using a subscriber terminal to increase the efficiency and effectiveness of operational performance. The training efficiency and effectiveness of this technology to the training environment will be documented to support ongoing USAF systems and potential commercial/dual-use platforms.

Dual Use Commercialization Potential: Successful Phase III Dual-Use Commercialization will result in transition of the messaging system simulation training technology to areas assessed by Air Force Space Command as deficient in training and to assist current USAF space and satellite systems. At least one dual-use/commercial application of this technology will allow advancement in communication and simulation technology. This technology could also provide applications in the private sector and other government agencies to assist in maintaining operational effectiveness.

Related References:
1. Coverdale, David R. (1995). Potential Applicatons of the ORBCOMM Global Messaging System to US Military Operations. Naval Post Graduate School, Monterey, CA. June.

2. Mahan, Robert P. (2001). Remote Distributed Simulation Kits for Team Decision Making. Georgia University,Athens, GA. 56 p.,July.

3. AFMC Training Systems Product Group Distributed Mission Training Home page: http://tspg.wpafb.af.mil/programs/dmt/default.htm

4. SBIRS Program Home page: http://www.laafb.af.mil

5. Chairman, Joint Chiefs of Staff, Joint Vision 2010. (1997).

KEYWORDS: Subscriber terminal, Instant messaging system, Student/Instructor interaction, Satellites systems, Satellite operations, Simulation modeling, Space Based Infrared System

AF03-057 TITLE: Attitude Control System Simulation

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Space (SP)

Objective: To research, develop and demonstrate an efficient simulation training system that would display different modes of the attitude control system.

Description: New technologies for space surveillance and operations require innovative advances in the rapid training of the operators for those systems. Currently, the operators required to interpret the modes of the attitude control system for satellites rely on antiquated training technologies to understand and interpret the different modes. In addition, current interpretation is dependent on a one-by-one mental and paper-based reasoning for this interpretation. When a launch is performed, the DSP tumbles in space, acquires the sun, and then acquires the moon. After these functions are performed, the system then goes into the six modes. An innovative simulation training capability is needed to assist the operator to interpret the current mode of the attitude control system. Research as to the best approach to develop simulation for operator observation, as well as an understanding and interpretation of the modes to facilitate transmission of the information to required sources is needed to preclude delays and deficiencies of the training system. Advances through research of this technology would assist in the advancement and enhancement of operator performance and support other developing space systems such as the Space Based Infrared System, Space Based Laser, Space Maneuvering Vehicle, as well as launch, orbital operations, telecommunications, and information management. The ability to visualize the six different modes in real-time (in random order) on a routine basis would increase not only the efficiency but also the effectiveness of operator performance. This would also provide rapid accountability and access of transmitted data immediately.

Phase I: Demonstrate the capability of a new approach to display training material for the acquiring and interpretation of the six (6) different attitude control system modes of satellites.

Phase II: The simulation prototype will be demonstrated to provide a proof-of-concept for acquisition and interpretation of the six modes of the attitude control system. The training effectiveness, evaluation, and assessment of the demonstrated application will be fully documented to support a current space system and a potential commercial/dual-use platform.

Dual Use Commercialization Potential: Successful Phase III Dual-Use Commercialization will result in transition of the training simulation software technology to assist current USAF space and satellite systems. At least one dual-use/commercial application of this technology will allow advancement in visual and interpretative technology. This technology could also provide applications in the private sector and other government agencies to assist in maintaining operational effectiveness.

Related References:
1. Marshak, W. P., Adams, T. J.,& Monk, D.L. (2000). Space Review Study: Human Factors Engineering's Role in Unmanned Space Operations. Sytronics,Inc, Dayton,Ohio 49 p. Feb.

2. Virtual Environments for Training. (1977). Office of Naval Research, Arlington, VA. Nov.

3. AFMC Training Systems Product Group Distributed Mission Training Home page: http://tspg.wpafb.af.mil/programs/dmt/default.htm

4. SBIRS Program Home page: http://www.laafb.af.mil

5. Chairman, Joint Chiefs of Staff, Joint Vision 2010. (1997)

KEYWORDS: Attitude control system, Satellite systems, Modeling and simulation, Satellite operations, Software modeling

AF03-058 TITLE: Simulation Models for Satellites

TECHNOLOGY AREAS: Information Systems, Space Platforms, Human Systems

ACQUISITION PROGRAM: Space (SP)

Objective: To research and develop a specific simulation technology with rotation and zoom capabilities to allow visuals of internal equipment and equipment bays for spacecraft.

Description: Significant investments are made each year for the continued development of highly-advanced and extremely sophisticated space platforms and vehicle systems. However, the training and support devices are inadequate. Simulation models of satellites are needed to assist in better diagnostic and preventive maintenance procedures. An innovative approach is sought to enhance training requirements for technicians to better predict and correct errors, anomalies, assess health and safety, and increase operational performance. The focus of the technician's job is to understand in a detailed manner how the space systems operate, monitor performance, and intervene when inconsistencies arise. New and advanced training simulation technologies are needed for the new generation of space systems that are rapidly approaching operational deployment. The capability of this simulation technology applies to areas including air, ground, sea, and space systems and subsystems requiring human intervention on all levels of diagnostic and preventive measures.

Phase I: Demonstrate the feasibility of an innovative approach to meet the needs of a simulation model to support spacecraft technicians.

Phase II: Develop an applicable prototype demonstration and/or proof-of-concept simulation model to assist space technicians with specific visual approaches to diagnostic and prescriptive measures within space subsystems. Demonstrate high commercial viability.

Dual Use Commercialization Potential: Successful Phase III Dual-Use Commercialization will result in transition of the simulation model technology to assist current USAF space and satellite systems. At least one dual-use/commercial application of this technology will allow advancement in simulation technology. This technology could also provide applications in the private sector and other government agencies to assist in maintaining operational effectiveness.

Related References:

1. AFMC Training Systems Product Group Distributed Mission Training Home page: http://tspg.wpafb.af.mil/programs/dmt/default.htm

2. SBIRS Program Home page: http://www.laafb.af.mil

3. Chairman, Joint Chiefs of Staff, Joint Vision 2010. (1997)

4. Mahan, Robert P, (2001). Remote Distributed Simulation Kits for Team Decision Making. Georgia University, Athens, GA. 56p., July.

5. Strategic Plan for Transforming DOD Training. (2002). Office of the Under Secretary of Defense for Personnel and Readiness. Director, Readiness and Training Policy and Programs.March.

KEYWORDS: Training simulation, satellites, Visual systems, Satellite operations, Software system modeling

AF03-059 TITLE: Through Screen Optical Head Tracker

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Human Systems

Objective: Develop an optical position and orientation tracking system that senses through rear-projection type screen material for use in wrap-around display systems.

Description: Current six degree-of-freedom (DOF) tracking systems require the use of a transmitter that is difficult to place within a weapons system trainer (WST) without being physically in the way of the pilot or without blocking the pilot's view. This is especially a problem in simulators with wraparound display systems, which are becoming the norm in military aircraft trainers. Magnetic tracking systems are the least obtrusive but these systems are prone to produce high error rates due to interference from the metal content of current WSTs. To compensate for the resulting distortion, magnetic systems require expensive magnetic field mapping for each specific cockpit. To satisfy the demanding requirements of the head-slaved imagery and symbology being installed in current and future training systems, an optical head-tracking system is desirable because it is more accurate, faster, and more reliable. Unfortunately current optical trackers employ large, bulky transmitters or transmitting arrays which would block significant portions of the pilot's display or would physically limit the pilot within the cockpit, or limit ingress and egress from the cockpit. A solution to this problem would be to transmit through the projection screens using wavelengths that are invisible to the pilot and, if possible, invisible to night vision goggles as well (i.e., no transmission from 400-1000 nm). The tracked part of the system should be small and lightweight so that it can be easily worn on the head, helmet-mounted display, hand, etc. The system should be designed in such a way that objective data regarding position, orientation, and movement could be obtained for the purposes of pilot performance aids. Phase I would result in a system design and a proof of concept demonstration; Phase II would result in a functional prototype to be set up and evaluated at the Air Force Research Laboratory's Warfighter Training Research Division (AFRL/HEA) for feasibility of use in a simulated night vision goggle system.

Phase I: System design and proof-of-concept demonstration. The system design should address such areas as scalability, durability, reliability, size, weight, precision, accuracy, sampling rate, ease of installation, data transmission, data formats, tracking modes, and motion prediction.

Phase II: Prototype system. Minimum sampling rate of position and orientation should not be less than 120 samples per second and as least as accurate as current magnetic trackers. i.e., 7.6 mm RMS position accuracy with all orientation capability. This system will be set up at AFRL/HEA and evaluated for use in the Night Vision Training System and any other position and orientation tracked technologies being developed for use in wraparound display environments.

Dual Use Commercialization Potential: Any training system, which requires unobtrusive tracking of head or body position and orientation could use this technology. A training system that requires augmented-reality within a virtual environment would benefit the most from this device. Placing a student within a realistic virtual environment with an augmented head-mounted display instead of sending the student to a distant location to be trained in a traditional manner could provide global availability for these types of training (e.g., Archeological studies of Egyptian tombs). It would be useful in airplane simulators using any form of head-slaved imagery or helmet-mounted cueing. It would also be useful in multicrew systems that allow aircrew movement within the cockpit when wearing simulated or real NVGs. The primary non-defense commercial applications are in the entertainment business and in education where CAVE-type display systems are often employed.

Related References:

1. Welch, G., Bishop, G., Vicci, L., Brumback, S., Keller, K., & Colucci, D. (Dec 20-22, 1999). The HiBall Tracker: High-performance wide-area tracking for virtual and augmented environments. Proceedings of the ACM Symposium on Virtual Reality Software and Technology 1999 (VRST 99), University College London. Best paper designation.

2. Chi, V.L. (April 1995). Noise model and performance analysis of outward-looking optical trackers using lateral efect photo diodes (TR95-012). Chapel Hill NC: University of North Carolina, Department of Computer Science.

3. Gottschalk, S. & Chi, V.L. (October, 1994). Sensitivity of system accuracy to fabrication tolerances in an outward-looking tracker (TR94-055). Chapel Hill NC: University of North Carolina, Department of Computer Science.

KEYWORDS: Head tracking, Head slaved imagery, Optical head tracking

AF03-060 TITLE: Command and Control Interfaces for Virtual Teams

TECHNOLOGY AREAS: Human Systems

Objective: Develop user interfaces that permit rapid distributed Command and Control (C2) meetings and decision-making.

Description: The current and future wartime environment calls for the ability to command and control aerospace forces by drawing information from and processing information at multiple, geographically separated sources. Interaction among C2 warriors is best performed when they are "face-to-face" with each other. However, collocation of the C2 elements is not always possible. Innovative virtual C2 interfaces, which allow distributed human interaction to be performed with the quality of "face-to-face" communications, need to be developed. New distributed video collaboration interfaces, include in, but not limited to, multi-modal inputs (e.g., 3D audio, speech recognition, haptics, etc.), mobile computing, and the use of avatars, offer the potential for developing virtual distributed C2 interfaces that will greatly enhance command and control decision making in a distributed C2 wartime environment. In addition video conferencing techniques and tools must also be developed that integrate distributed video collaboration interfaces to better organize conduct and manage distributed collaboration meetings. Examples of tasks that may be integrated are: action item management (including tracking and point of contact assignment), schedule handler, electronic interfaces, innovative map navigation techniques, systems administration tasks (which include managing multiple people speaking at once), local user communications as well as remote user to complete group communications.

Phase I: Develop a viable virtual "distributed command and control" interface design and demonstrate a conceptual "distributed virtual command and control" interface prototype(s). The distributed command and control interface design should use the assumption that broadband access exists. The human communication/interaction attributes, which are associated with the critical tasks involved in distributed command and control decision making processes, should be identified and innovative virtual distributed C2 assistance/solutions for the identified C2 tasks should be provided.

Phase II: Implement the distributed command and control interface by integrating the system designed in Phase I. The offeror shall develop a viable demonstration that demonstrates the use of the distributed command and control interface.

Dual Use Commercialization Potential: Follow on activities are expected to be aggressively pursued by the offeror; namely, seeking opportunities to integrate the system and transition the completed system into commercial industry. This topic has application to almost all phases of business where more efficient meetings are required.

Related References:
1. Olveres, J., Billingurst, M., Savage, J., Holden, A (1998). Intelligent, Expressive Avatars. In Proceedings of First Workshop on Embodied Conversational Characters (WECC '98)

2. Billinghurst, M. and Kato, H. (1999). Collaborative Mixed Reality: Research Results Presented at Virtual Worlds Consortium, May, 1999 (R-99-12). Seattle, WA: University of Washington, Human Interface Technology Laboratory

KEYWORDS: User interfaces, Dynamic adaptive computing, Visual, Aural, Haptics, Human interfaces, Avatars, Video teleconferencing

AF03-061 TITLE: <u>Multisensory Integration for Pilot Spatial Orientation</u>

TECHNOLOGY AREAS: Human Systems

Objective: The objective of this research is to optimally integrate multisensory displays to help pilots maintain their spatial orientation in flight or to recognize and recover from spatially disorientating situations.

Description: Spatial disorientation (SD) accidents result in lost lives and aircraft, and continue to cost the Department of Defense over $300 million per year. For the past three decades, the percentage of accidents attributed to SD has remained relatively constant. Traditional approaches to solving the SD problem (other than training efforts) have focused primarily on visual display symbology testing and implementation. With no apparent decline in the accident rate, an alternative approach is warranted. Members in various branches of the Air Force Research Laboratory's Human Effectiveness Directorate (HECI, HECB, HEPA, and HEM) are interested in pursuing an approach that involves taking advantage of human sensory integration by providing orientation information via multiple sensory modalities to help combat the problem of pilot SD. The goal of this effort is to determine and capitalize upon the combined effects of visual attitude display symbology, 3-D localized audio, tactile stimulation, and other applicable technologies to help pilots maintain attitude and position awareness, and to rapidly recognize and recover from spatially disorienting situations. Technologies investigated should include the aforementioned types of displays, but are not limited to these three. There is limited research on each of these displays individually, but what is lacking is a methodology for the integration and testing of these technologies for the given application. The challenge will be to determine the best displays for this application and to integrate them synergistically to provide an optimized suite of displays for improved pilot spatial orientation. The result of such as effort has the potential for significantly reducing spatial disorientation accidents and incidences, as well as reducing pilot workload, increasing pilot situation awareness, and ultimately increasing mission effectiveness.

Phase I: Conduct literature review of pertinent research. Identify and justify the components of the integrated suite of displays for the SO/SD application. Provide a plan for integration of the displays and display symbologies, and testing of the suite of displays.

Phase II: Execute integration plan from Phase I. Develop and fabricate the integrated displays and symbologies that meet the objectives of the topic. Modify the design/refine the integration as necessary. Demonstrate and validate the performance benefits of the integrated technologies in a human-in-the-loop environment.

Dual Use Commercialization Potential: Phase III military applications include incorporation of multisensory technologies into the fighter aircraft cockpit. The fighter aircraft cockpit will have a helmet-mounted display and 3-D localized audio. The Tactile Situation Awareness System (TSAS) has been preliminarily tested for fighter aircraft applications. Phase III commercial applications include general aviation applications, as well as entertainment application, such as virtual environments and gaming. Additional commercial applications could include augmented wearable computers, and aids for physically challenged individuals.

Related References:
1. Benson AJ. Spatial disorientation in flight. In: Gillies JA, ed. A textbook of aviation physiology. Oxford: Pergamon Press; 1965:1086-1129.

2. Collins DL, Harrison G. Spatial disorientation episodes among F-15C pilots during operation desert storm. J Vestibular Res 1995; 5:405-10.

3. Cone SM, Hassoun JA. Attitude awareness enhancements for the F-16 head-up display. Wright-Patterson AFB, OH: AFMC, 1992. Tech Report ASC-TR-92-5017

4. McGrath BJ, Suri N, Carff R, Raj AK, Rupert AH. The role of intelligent software in spatial awareness displays. 3rd Ann Symp Exhibition on Situational Awareness in the Tactical Air Environment 1998; 143-152.

5. Rochlis JL, Newman DJ. (2000). A tactile display for International Space Station (ISS) extravehicular activity (EVA). Aviat Space Environ Med 2000; 71:571-

KEYWORDS: spatial orientation, disorientation, displays, 3-D audio, tactile displays, multisensory displays, sensory displays

AF03-062 TITLE: Stand-off Detection of Biological Warfare Agents by Laser-induced Breakdown Spectroscopy (LIBS)

TECHNOLOGY AREAS: Chemical/Bio Defense

Objective: Develop a LIBS standoff detection and identification system capable of detecting and identifying biological agents whether they are located in aerosols, shallow aquatic environments, or on the surface of solid materials.

Description: The technical foundation is in the linking of two established technologies: LIBS and Applied Microbiology. Recent advances in LIBS have been brought about by the introduction of ultra-short lasers that can be focused to produce both localized plasmas and filaments from which broadband spectral data can be generated on complex organic compounds, as well as the more traditional inorganic specimens. By applying this enhancement of LIBS to the fields of applied microbial and viral physiology and biochemistry, a new and potentially powerful capability for standoff biological agent detection and identification may now be feasible. LIBS is a form of atomic emission spectroscopy utilizing a high power density pulse focused to a point in the atmosphere or on the surface of a solid or liquid. At the focal point, a plasma or "spark" forms resulting in the vaporization of portion of the surrounding materiel. The vaporized materiel emits a broad spectrum of electromagnetic radiation (from UV to IR) as a single pulse, which can be analyzed by the appropriate spectrophotometric techniques (such as time resolved atomic emission, time resolved luminescence, or time resolved absorbance alone or in combination) to determine the molecular composition of the materiel. It is the availability of such a large amount of spectral information, potentially from 200nm to 12 microns, by a single remote interrogation of an area of interest, be it air, land, or water, which makes this a compelling technology to pursue.

Phase I: Determine the applicability of LIBS in analyzing complex biochemical compounds and the next level of complexity in organic mixtures, that of, resolving the identifying spectral characteristics of microorganisms. Design a prototype system.

Phase II: Develop, demonstrate, and validate an operational portable LIBS designed during Phase I. The technical approach may involve parallel development in both laser spectroscopy for the hardware portion of the system and toxin and microbial identification by inviolable characteristics, which forms the basis for the signal processing algorithms necessary for high confidence detection and identification. Validation should be considered using spore and vegetative forms of B. subtilis, B. thuringiensis, B. anthracis (A/G), and Pseudomonas as members of the mixed cultures.

Dual Use Commercialization Potential: Use by military and emergency responders (police, firefighters, medical personnel) to CBWAs released by terrorists within the United States.

Related References: Cole, Leonard A. The Specter of Biological Weapons. Sci Am. 1996 Dec;275(6):60-5.

KEYWORDS: Anthrax, Biological Warfare Agents, Directed Energy, Laser.

AF03-063 TITLE: <u>Personnel Real-time Operational Toxic Exposure Characterization Tool (PROTECT)</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

Objective: To employ emerging technologies to identify toxic substance effects upon the warfighter before they can induce a reduction in health and/or operational performance.

Description: Operational toxic environments, from theater-level combat to humanitarian missions, are becoming more hazardous than infectious disease risks as the major cause of non-battlefield-related morbidity and mortality. An increasingly important issue in force protection is the toxicology associated with potential chemical exposures at deployed sites. Many emerging nations do not have adequate environmental monitoring. Deployed personnel may be exposed to toxic chemicals as a result of industrial accidents, intentional or unintentional activities of various forces (enemy or friendly) or sabotage. Current methods of determining toxic exposures to the war fighter are not adequate to prevent serous health effects such as was induced by Agent Orange in Vietnam or to predict and prevent the mystery of the Gulf War Syndrome like disease. The emerging technology of toxicogenomics may be able to identify toxic effects upon the war fighter before they can cause any decrease in mission performance or induce a disease process that may not be manifested for several years. Development of a novel human monitoring methodology must provide real-time detection of potential toxic injury and incorporate the latest toxicity detection technologies, microfabrication technologies and improved polymers and resins into a small, light, easy to operate and logistically supported materiel for operational users.

Phase I: Phase I will consist of research leading to the establishment of a human cell system for toxicogenomic assessment that can also be obtained by a minimally invasive procedure from deployed personnel (i.e. blood cells, epithelial cells, endothelial cells). Representative chemicals found at deployed sites, covering a range of physio-chemical properties, will then be used to determine if differences in patterns of gene expression can be established for various classes of chemicals. From this data, studies will be performed to determine what set of genes will be required to give accurate characterization and identification of deployment toxicologic (DT) risks to personnel at deployed sites. Also, recommendations will be made regarding whether a designed DT gene chip can be adapted for use in a small, field-devise to monitor deployed personnel prior to and during deployment.

Phase II: Phase II would consist of developing prototypes of DT gene chips and the human monitoring device specified in Phase I and would also include validation testing of these prototypes.

Dual Use Commercialization Potential: A portable human monitoring device with the above desired characteristics (size, weight, rapid characterization of potential toxicity, ease of operation) could be a highly marketable item to industry for monitoring pollution and contamination exposure at manufacturing facilities or for any other types of industry where industrial processes have the potential to lead to pollution or contamination of soil, water or air.

Related References:
1. Burchiel, S.W., Knall, C.M., Davis, J.W. 2nd, Paules, R.S., Boggs, S.E. and Afshari, C.A. Analysis of genetic and epigenetic mechanisms of toxicity: potential roles of toxicogenomics and proteomics in toxicology. Toxicol Sci. 59(2): 193-5, 2001

2. Fielden, M.R. and Zacharewski, T.R. Challenges and limitations of gene expression profiling in mechanistic and predictive toxicology. Toxicol Sci. 60 (1): 6-10, 2001

3. Smith, L.L. Key challenges for toxicologist in the 21st century. Trends Pharmacol Sci. 22(6): 281-5, 2001

4. Fredrickson, H.L., Perkins, E.J., Bridges, T.S., Tonucci, R.J., Fleming, J.K. Nagel, A., Diedrich, K., Mendez-Tenorio, A., Doktycz, M.J. and Beattie, K.L. Towards environmental toxicogenomics – development of a flow-through high-density DNA hybridization array and its application to exotoxicity. Sci Total Environ. 274(1-3): 137-47, 2001

5. Aardema, M.J. and MacGregor, J.T. Toxicology and genetic toxicology in the new era of 'toxicogenomics': impact of '-omics' technologies. Mutat Res. 499(1): 13-25, 2002

KEYWORDS: toxicogenomics, gene expression profile, toxicology, enviro-toxicologic, human, microfabrication, occupational health

AF03-064 TITLE: Simulation and Training Development to Enhance the Tactical Knowledge and Readiness of Information Warfare Teams

TECHNOLOGY AREAS: Information Systems, Human Systems

Objective: Develop a high fidelity integrated training suite (ITS) to develop and enhance the tactical knowledge and mission readiness of information warfare (IW) teams.

Description: This effort will develop a distributed and collaborative training and rehearsal simulation environment for information warfare teams. Given the proliferation of information, a number of concerns must addressed. These are related to the following: (a) identifying and gathering primary information; (b) monitoring information sources and quality, (c) assimilating information in ways so that it can be used efficiently and effectively; and (d) determining when the information being used has been corrupted or compromised. In addition the current OPTEMPO severely limits opportunities to adequately train and rehearse needed competencies for such a complex and dynamic environment. This effort will conduct exploratory research to develop a high fidelity training and rehearsal capability for intelligence operators. These operators engage in a wide variety of complex activities for which no realistic training or rehearsal capability exists today. Example activities include monitoring and evaluating incoming civilian and military information, identifying key components or characteristics of the information, identifying inconsistencies in the information that would indicate data compromise or the presence of critical intelligence data, and providing near-real-time evaluation of data to the human-in-the-loop for decisionmaking. As part of this effort, a detailed cognitive and behavioral work analysis will be performed to key tasks and performance requirements needed for information warfare and to specify the initial knowledge and skills required for relevant operational IW domains. In addition, this effort will identify the critical mission qualifying knowledge and skills and competencies associated with combat mission ready information warfighters. This information is critical to the specification of training and rehearsal objectives, the development and evaluation of competency-based training and rehearsal scenarios, the characteristics of a high fidelity simulation environment for training and rehearsal and performance measures and knowledge assessment tools to facilitate the continuous diagnosis and remediation of critical IW and intelligence operations competencies. The environment will permit near-real-time fusion of large data constellations in a realistic, high fidelity environment that also provides a means of distributing mission training for information warfare training and rehearsal to non-co-located team members. Ultimately, the integrated training and rehearsal capability to be developed will facilitate the individual and collective mastery of critical IW competencies. Starting from a knowledge, skills and competency framework will provide IW warfighters with critical capabilities they do not have today. It will also provide data for AF leaders to ensure that the content and structure of initial training, mission qualifying training and recurring training events are producing the desired level of mission readiness for the warfighters.

Phase I: Phase I activities will result in proof-of-concept software methods defining critical IW knowledge requirements and mission essential competencies critical IW missions and operational domains. Phase I will also demonstrate the feasibility of developing an automated knowledge acquisition and assessment system for teams as part of the ITS development. As a precursor to Phase II activities, knowledge and competency requirements will be matched to instructional principles and training strategies so that detailed specifications of the ITS can be elaborated in Phase I. Phase I will also provide specifications for an integrated knowledge assessment, training delivery, and performance measurement capability for individual IW warfighters and IW teams.

Phase II: Phase II will develop and demonstrate a suite of tools, techniques, methods and a common architecture for knowledge assessment, scenario design and delivery, and performance measurement for IW teams in realistically simulated combat environments. As an additional activity in Phase II, two demonstrations of the training and performance assessment capabilities of the IW ITS will be conducted. Training effectiveness and mission impact evaluations will be accomplished with actual IW teams in a distributed context.

Dual Use Commercialization Potential: This effort will provide an integrated suite of tools, technologies and a general architecture for IW training and rehearsal. The benefits from such a capability to government and private sector agencies include targeting training and rehearsal activities and content to remediate specific knowledge shortfalls and reducing operator time-to-proficiency and

Related References:
1. Bennett, W., Jr., Arthur, W., Jr. (1997). Factors that influence the effectiveness of training in organizations: A review and meta-analysis. Interim Technical Report, AL/HR-TR-1997-0026.

2. Fowlkes, J. E., Lane, N. E., Salas, E., Franz, T., & Oser, R. (1994). Improving the measurement of team performance: The TARGETS methodology. Military Psychology, 6, 47-63.

3. Guzzo, R. A., & Salas, E. (1995). Team effectiveness and decisionmaking in organizations. San Francisco: Jossey Bass.

4. Salas, E., Bowers, C. A., & Cannon-Bowers, J. A. (1995). Team processes, training, and performance. Military Psychology, 7, 53-139.

5. Tannenbaum, S. I., Beard, R., L., & Salas, E. (1992). Team building and its influence on team effectiveness: An examination of conceptual and empirical developments. In K. Kelly (Ed.), Issues, theory, and research in industrial/organizational psychology (pp. 117-153). Amsterdam: Elsevier

KEYWORDS: Affordability, Criterion development, Distributed mission training, Information warfare, Knowledge assessment, Performance measurement, Readiness evaluation, Team effectiveness, Workgroup effectiveness

AF03-065 TITLE: Destruction of Chemical/Biological Warfare Agents using a Portable Microwave Emitter

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop and Demonstrate a Portable High-Powered Microwave Emitter to Destroy Chemical /Biological Warfare Agents (CBWAs).

DESCRIPTION: Methods to destroy CBWAs without damaging the surrounding environment (e.g., paper, rubber gaskets, electronics) are desired. One such method is the development of chemical solutions, such as diazoluminomelanin (DALM), that both bind to CBWAs (e.g., anthrax) and enhance microwave absorption. Exposure of these solutions to high-powered microwaves results in the destruction of CBWAs via microwave-induced cavitation. However, the footprint of the current transmitter technology to produce the electromagnetic fields (1.2 GHz, 10 pps (pulse repetition rate), 6 µsec (pulse duration), 100 kV/m (peak E-field)) required to activate these solutions is relatively large, and thus it is not feasible to transport them for use in the field or hospital. Desired is the research and development of an innovative portable high-powered microwave emitter to activate these chemical solutions. A creative antenna design to serve as an applicator may be required.

PHASE I: Determine technical feasibility of constructing a portable high-powered microwave emitter capable of delivering an electromagnetic field (1-2 GHz, 4-8 µsec pulse duration, pulse repetition rate up to 100 pps, with up to 100 kV/m peak E-field at 1 meter). The emitter and applicator should be transportable on a platform smaller than the bed of a Humvee.

PHASE II: Develop, demonstrate, and validate an operational portable high-powered microwave emitter designed during Phase I. Enhancement of the design to obtain 100 kV/m at 3 meters would be desirable, but air breakdown within 3 meters must be considered. Power requirement should be 110 or 208 volt and < 30 amps. Cooling of the system should be incorporated into the emitter or should require only a minimal number of external attachments. The applicator should be maneuverable to permit sweep decontamination over a wide surface area.

PHASE III DUAL USE APPLICATIONS: Emergency responders (police, firefighters, medical personnel) to CBWAs released by terrorists within the United States, industrial toxic spills, and for decontaminating hospital environments, clothing, and skin.

REFERENCES:
1. Kiel, J.L., Seaman, R.L., Mathur, S.P., Parker, J.E., Wright, J.R., Alls, J.L. and Morales, P.J. Pulsed Microwave Induced Light, Sound, and Electrical Discharge Enhanced by a Biopolymer. Bioelectromagnetics, 20: 216-223, 1999.
2. Kiel, J.L., Parker, J.E., Morales, P.J., Alls, J.L., Mason, P.A., Seaman, R.L., Mathur, S.P. and Holwitt, E.A. Pulsed Microwave Induced Bioeffects, IEEE Transactions on Plasma Science, 28(1): 161-167, 2000.
3. Kiel, J.L., Sutter, R.E., Mason, P.A., Morales, P.J., Alls, J.L., Holwitt, E.A., Seaman, R.L., and Mathur, S.P. Directed Killing of Anthrax Spores by Microwave-Induced Cavitation via Specific Binding of Organic Semi-Conductor. IEEE Transactions on Plasma Science, In press.

KEYWORDS: Directed Energy, Radio Frequency Radiation, Diazoluminomelanin (DALM)

AF03-069 TITLE: Head Mounted Miniature Display

TECHNOLOGY AREAS: Information Systems, Human Systems, Weapons

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: A high luminance miniature display that simplifies head-mounted display (HMD) applications for pilots and special tactics operators.

Description: Defense applications for miniature displays in combat include fighter/bomber aircraft pilots and ground-based forward air controllers. There is a critical need for a miniature display, based on any technology that does not require high voltage, to replace miniature cathode ray tubes (CRT) in combat pilot helmet mounted display (HMD) systems. Special tactics operators on the ground, work as a team with combat pilots and require displays to provide them a common picture of the tactical battlespace with the pilots they control. One military-unique application is the potential replacement of miniature CRTs in Joint Helmet Mounted Cueing System (JHMCS) tactical fighter helmets. Any display device design approach may be proposed, including light valve, direct-write, and emissive. Each approach must be capable producing an image that is wide-angle (quasi-Lambertian) in intensity distribution. Monochrome green is sufficient initially, but a realistic pathway to color is highly desirable. The device should ultimately be capable of ultrahigh luminance of 24,000 cd/m2 (7,000 fL) in day mode, yet also, very dim operation in night mode of 0.1 cd/m2 (0.03 fL); the electronics to achieve this dynamic range should be affordable. Lower weight, volume, and power than current microdisplays is highly desirable. The device technology should be capable of generating a resolution of at least 1.3 megapixels per frame for an image size of about 15 mm. Also, a version that has ultra-low weight and power requirements is sought for dismounted forward air operations controllers.

Currently fielded HMDs that produce a virtual image viewable through a clear visor in daylight conditions use miniature CRT display technology. The miniature CRTs require high voltage, complexity, and cost. The high voltage forces the use of an additional power supply, special wiring in the cable from the helmet to off-body electronics mounted in the aircraft or portable unit, and elaborate safety components to avoid shock and fire hazards. Furthermore, the miniature CRTs add weight, consume considerable power, complicate the design of the HMD optics, take up valuable space in the helmet, and require expensive optical coatings on the see-through visor to achieve sufficient image contrast in high ambient illumination conditions.

There are no currently fielded HMDs for the special tactics combined air operations controllers working on the ground to guide joint service air strikes.

Phase I: A manufacturable design is to be developed that takes into account issues including reliability and maintainability for environments typical of both the defense and commercial electronics markets. This design should include a roadmap leading to a Phase II prototype and Phase III products, both civil and military. A realistic commercialization plan is mandatory and should describe a series of initially simple, but ever more sophisticated, product introductions over time.

Phase II: A prototype miniature display is to be delivered to the Air Force Research Laboratory for evaluation along with a revised roadmap for Phase III commercialization and transition. Characteristics desired in this prototype are as follows: (a) no-high voltage power supply for components mounted on the head or worn on the body; (b) capable of generating an image viewable through a clear visor against daylight illumination conditions; (c) potential for follow-on integration with night vision, goggle, and imaging systems. The Phase II prototype should be sufficient to evaluate the potential to develop products to meet the needs for combat aircraft pilots teamed with their special tactics battle space air operations controllers on the ground. The prototype must also demonstrate the potential for success in one or more civil commercial markets.

Dual Use Commercialization Potential: Phase III is expected to result in a manufacturable device meeting or exceeding the specification from an original equipment manufacturer of civil or military products. Displays are dual use and it is anticipated that commercial applications will also be developed for miniature display markets including but not limited to camcorder viewfinders, presentation projectors, and near-eye viewers as peripheral options for wearable electronics. Market success in Phase III is necessary to provide a commercial infrastructure that defense integrators can access to produce military versions of the new miniature displays to be developed under this effort.

Related References:

1. Proceedings of SPIE Volume 4711, Helmet Mounted Displays (2002), available from: www.spie.org .

2. Pat O'Donnell and Anna Doi, "Micro displays in Digital Cameras," Information Display, Vol. 17, No. 12, p 16-21 (Society for Information Display, San Jose CA, December 2001). Available from www.sid.org .

KEYWORDS: Helmet and Head Mounted Displays, Near-Eye Displays, Virtual Image Viewers, Miniature Display, Miniature Cathode Ray Tube

AF03-075 TITLE: Automated Mission Planning Tools for Simulation Based Acquisition (SBA) of C2 Systems

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Electronic Systems Center (ESC)

Objective: Develop automated theater air campaign mission planning tools to support simulation-based development, synthesis, and evaluation of command and control systems.

Description: The Air Force's Joint Synthetic Battlespace (JSB) will provide a common modeling and simulation environment to support acquisition, training, test and evaluation, and analysis. One of the specific targets for SBA is the necessary automated C2 systems for Air Operations Centers (AOCs). To facilitate this process, a means is needed to automatically generate doctrine and scenario appropriate air battle plans for theater air campaigns. A mission plan must be developed to account for friendly resource allocation and scheduling to optimally engage an enemy force defined from intelligence information. The development of such effective mission plans may be accomplished through the use of numerical optimization techniques such as genetic algorithms (GAs). Given intelligence information about enemy resources and configuration, well-developed mission goals and detailed information about available resources and restrictions applying to them, optimal mission plans can be developed via GAs. GAs provide the opportunity to optimally configure and schedule air strikes and coordinated attacks based on the definition of high level goals such as mission effectiveness with respect to overall objectives.

Phase I: 1) Evaluate the potential to apply genetic algorithm optimization techniques to effective mission planning to support simulation based acquisition initiatives. 2) Apply commercial off-the-shelf (COTS) software to investigate the potential to integrate these technologies into JSB. 3) Demonstrate the effectiveness of the integrated tool set on a limited-scope tactical scenario of relevance to the USAF.

Phase II: Build an expanded-scope prototype and demonstrate it on an expanded-scope tactical scenario. Provide analyses showing scalability to real-world scenarios.

Dual Use Commercialization Potential: The development of automated mission planning and scheduling tools that factor in overall goals, resource allocation issues, and other constraints has application in many commercial domains. The technology has application to a range of transportation problems, for example the optimal use of carriers by transportation companies (e.g. airliners, trucking companies). Similarly, optimal maintenance of an inventory is highly desirable and could benefit significantly from an automated approach.

Related References:
1. Ruda, H., Burge, J., Aykroyd, P., Sander, J., Okon, D., and Zacharias, G., "Distributed course of action planning using genetic algorithms, XML, and JMS", Proceedings of the SPIE 15th Annual International Symposium on Aerospace/Defense Sensing, Simulation, and Controls, April 2001, Orlando FL

2. Mulgund, S., Harper, K., Krishnakumar, K., and Zacharias, G., "Large-Scale Air Combat Tactics Optimization Using Genetic Algorithms," Journal of Guidance, Control, and Dynamics, Vol 24. No. 1, January-February 2001.

KEYWORDS: Modeling and Simulation, Command and Control, Genetic Algorithm, Simulation Based Acquisition

AF03-076 TITLE: Millimeter Wave Communications for Force Protection

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: Electronic Systems Center (ESC)

Objective: Investigate the military utility of employing millimeter wave technology for communication of covert and non-covert intrusion detection systems employed for general USAF Force Protection, Anti-Terrorism and Homeland Defense applications.

Description: The system would be used to communicate both narrow and wide bandwidth sensor data, surveillance video and related control signals among field devices and command, control and display equipment. The intent is to take advantage of atmospheric absorption bands to establish low probability of intercept short-range (at least 250 meters and up to 1500 meters) communications links for physical security related data. The communications capability must be useable for low power demand (battery operation), portable use (very small volume), point-to-point and wide-area-network communications, and provide industry standard interface outputs for use by external systems. This effort shall address the end-to-end data link capability only; the input devices and command, control and display equipment are not included. The communications link must be useable as a direct replacement for existing radio, wire and optical fiber links as well as future independent applications.

Phase I: Select an appropriate portion of the radio spectrum that can be allocated for military use and perform preliminary investigations of available micro-technology useable for this purpose. Determine preliminary system and equipment design parameters, specifications and interface standards. Submit a report describing the proposed preliminary design and recommendations for a Phase II program.

Phase II: Complete the design of a demonstration unit. Build and optimize a demonstration system by conducting tests in the expected operating environment. Demonstrate the capability of the system to be used as the communications medium in place of radio, wire and optical fiber links at an Air Force Test Site. Demonstrate unique system capabilities offered by the system. Provide a report of Phase II results including documentation of the demonstrator design, the test results and recommendations for Phase III.

Dual Use Commercialization Potential: This communications capability will support (USAF) Force Protection and Anti-Terrorism applications such as Air Base Defense, Physical Security, and Police Services applications. It will also be useful to the Civil Community in a Counter-Terrorism and Emergency Preparedness, First Responder role.

Related References:

1. Rogers, Robert; Koerner, Matthew A; “Test and Development of High Data Rate Millimeter Wave Data Links Over Low Elevation Paths for Physical Security Systems”, University of Texas at Austin, 2 July 1998, Technical Report ARL-TR-98-2.

2. “Millimeter Wave Propagation”, Spectrum Management Implications, FCC New Technology Development Division, Washington DC.

3. Ippolito, L. J., “Radio Wave Propagation in Satellite Communications”, NY: Van Nostrand Reinhold, 1986, Ch 4 & 7.

KEYWORDS: Millimeter Wave, Communications, Data Link, Wide Bandwidth, Force Protection, Anti-Terrorism

AF03-077 TITLE: Application of Wireless Communications for Transfer of Cryptographic Key Material

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Electronic Systems Center (ESC)

Objective: Investigate the feasibility of using wireless communications to distribute cryptographic keys to remote/deployed cryptographic units.

Description: The use of wireless communications is increasing at a rapid pace in both the DoD, Federal, and commercial sector. Its ease of use, mobility, and affordability are making it the first choice, not the worst choice, for deployed units who do not have, or cannot put, a communications infrastructure in place. The technology to use wireless communications is maturing quickly and it is now being looked at as a potential solution for quick and easy transfer of protected cryptographic key material to remote/deployed units. This key material is used by cryptographic devices to encrypt data so it can not be understood and subsequently used by unauthorized individuals. Areas of concern about the use of wireless communications that need research, include:
· Ease of data capture by unfriendly elements & level of encryption required to prevent this
· Authentication between trusted units when sending and receiving (i.e., what OSI level)
· User friendly operation of the devices
· Affordability of the devices
· Device vulnerability to friendly/hostile electronic interference
Cryptographic key material susceptibility to data modification

Phase I: Investigate the feasibility of developing a device that attaches to the fill port of selected cryptographic devices to allow protected transfer of cryptographic key material. Look at current state-of-the-art equipment (if any) available to securely transmit this data and then lay out a (new) design to enhance the capabilities based on the areas of concern listed in the Description above. The end products of Phase I will be the specification of the device that fits on the cryptographic fill port and the selected set of devices to be used in the Phase II investigation.

Phase II: This will consist of three concurrent activities.
1) Fabricate a prototype receiver to be used with the selected cryptographic devices from Phase I.
2) Use the prototype receiver over wireless communications to document vulnerabilities and then find/suggest methods for alleviating those vulnerabilities.
3) During the fabrication and testing and evaluation process, formulate the specific areas of risk that the DoD will need to address before wireless communications can become a general use technology for transfer of cryptographic key material.

Dual Use Commercialization Potential: These devices will replace hardwired cables enabling much easier and faster (timeliness) transfer of cryptographic keys. It will mean that key material can be transferred more quickly to remote/deployed units. It will also be useful to any commercial corporation that uses cryptographic algorithms to protect sensitive data.

Related References: Wireless Local Area Network Vulnerability Assessment, Stephen S. Yoon, The MITRE Corporation, MITRE Working Note

KEYWORDS: wireless, cryptographic, key, encryption, data transfer, vulnerability, susceptibility

AF03-078 TITLE: Commercialization of Software Model Architecture Visualization Tool

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Electronic Systems Center (ESC)

Objective: Develop a communications architecture visualization tool to the extent that is can be marketed commercially.

Description: Much recent work has been performed to improve the tools available for model architects to design complex communications networks. The most promising of these tools uses Colored Petri Nets (CPNs) as its graphical design language, but the designs created using it lack the visual detail needed to impart a thorough and comprehensive understanding of the network's performance to those assigned to review, approve and use it. This deficiency can be corrected by improving the way network traffic is visually displayed to the end user. The contractor shall investigate various display methodologies, including the use of three-dimensional imagery, dynamic motion that simulates the movement of resources along various network threads and a virtual reality environment that immerses the viewer in the network as an active participant. The goal of the research and development activity is a visualization capability that will improve comprehension and understanding of the model's design characteristics for operational and management personnel who are not modeling experts. The software package should have the capability of providing the user with a computer generated immersive virtual reality environment and interfaces to the user interface devices on the market.

Phase I: Review the current status and capabilities of a variety of visualization tools to determine which techniques most closely meet the requirements of commercial and military end users. Each technique shall be evaluated in terms of its ability to improve rapid comprehension and understanding of a proposed model architecture's characteristics. The contractor shall identify the technique(s) that most closely meets these requirements and develop a plan for implementing a visualization capability in a CPN graphical generator/editor. We encourage Phase I applications that focus on military space operations, such as the visualization of satellite health degradation due to intentional and unintentional actions.

Phase II: Develop a commercial software tool that displays a network architecture, modeled as a CPN, in a visual format that improves comprehension and understanding of the network's characteristics. This tool shall provide a visual environment to the end user that expands upon the flat, non-detailed images used in the CPN design methodology. This visualization capability shall be integrated into a commercial CPN generator/editor to provide a comprehensive design and qualitative model evaluation capability to end users. It shall support the parallel quantitative evaluation capability provided by model simulation tools.

Dual Use Commercialization Potential: The desired product of Phase III is a robust, off-the-shelf architecture visualization tool for use in defense and commercial automated information system development applications and discrete manufacturing applications.

Related References: System Engineering Approach for the Migration of Computer Based System, M. Makhlouf et al., International Conference on System Engineering, July 1996, Boston MA

KEYWORDS: Modeling and Simulation, System Architecture, Communications Architecture, 3D visualization, immersive/augmented virtual reality

AF03-079 TITLE: <u>Multiple Security Level Collaboration</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Human Systems

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Joint Battlespace Infosphere (JBI) Technology for Coalition Warfighter Multi-level Security Collaboration and Interoperability.

Description: In recent years, multinational coalitions have assumed an increasingly prominent role in military operations. These coalition forces face many of the same information dissemination and accessibility issues addressed in US initiatives, such as Joint Vision 2010, with the added complexity of foreign disclosure policies and information sharing restrictions. Cross-boundary information exchange mechanisms, such as multi-security level controlled interfaces, provide a sound foundation for investigating technology enhancements, which can increase interoperability between coalition members and significantly increase the overall effectiveness of the coalition forces. Collaborative Targeting, Collaborative Mission Planning, Collaborative Bomb Damage Assessment, and Effects based planning will all require real time or near real time collaboration between Intelligence Analyst operating at the Top Secret – SCI level and Command and Control Operators operating at Secret and Coalition Secret levels. There are other stated Unified Command needs for Collaboration between Intelligence organization and coalition partners at Top Secret. Given the increasing interest in using controlled interfaces to facilitate coalition information exchange, exploratory development is needed in the area of Real Time (RT) security filters. Encryption strengths must be evaluated against performance penalties. This Program needs to accomplish "Multiple Security

Level Collaboration" to satisfy these operational requirements. The solution should include use of DOD Collaboration tools of H.323, H.320, T.137 and T.120 devices across security boundaries and coalition boundaries. Intelink and Internet are very similar in structure, creating multilevel secure products for one will provide viable commercial products for the other, therefore bidders are not required to possess DoD security clearances to work or propose on this effort.

Phase I: Investigate and develop a multi-level secure architecture that will support real-time collaboration across dissimilarly classified networks. Document the architecture using industry standard UML-formatted specifications. Ensure the architecture will be compliant with existing network infrastructure. Make recommendations for implementation.

Phase II: A dual use Intelink/Internet commercial application is sought. Develop prototype, including security mechanisms and support for several media types. Measure its performance under varying degrees of stress, such as bandwidth limitations, congested nodes, etc. Investigate and integrate commercial security policy servers that will allow users to easily define security policies governing collaboration activities.

Phase III Dual Use Applications: Both military and commercial applications can benefit from this research. The US Military may share data collaboratively with coalition forces, without compromising national security. Commercial companies may use MLS collaboration to share ideas for a joint program, and be able to keep company proprietary data private.

Related References:
1) United States Air Force, Scientific Advisory Board, "Report on Building the Joint Battlespace Infosphere Volume 1&2 SAB-TR-99-02" December 17,1999
2) Douglas Poore, poored@rl.af.mil, "Joint Warfare Interoperability Demonstration (JWID) Consistent Battlespace Picture (CBP) Implementation Plan (JW009)" March 10, 2000
3) U.S. News & World Report, October 8, 2001, Page 27-30, "Finger-pointing , fingerprints"

KEYWORDS: Secure Collaboration, Automatic Indexing, Multimedia Archive Systems, Metadata Tagging

AF03-080 TITLE: Component Generation And Integration For The ESC Scheduler Product Line

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Develop a capability to rapidly generate tailored and optimized scheduling engines that meet exact Air Force user needs.

Description: The U.S. Air Force Electronic Systems Center (ESC) Software Infrastructure Product Area Directorate (PAD) has a mission requirement to provide Command & Control (C2) Web Services to Air Force users. These services are planned to include multi-resource unit level scheduling. A current difficulty is the ability to quickly, efficiently, and cost-effectively provide resource scheduling capabilities that support myriad variations in operational processing requirements. The PAD must be capable of rapidly generating and sustaining scheduler variations for specific customers (e.g., Joint Strike Fighter). This topic area addresses the need to develop an advanced capability to rapidly generate custom scheduling engines for variations in operational requirements - custom, computer generated code that is highly efficient, guaranteed correct, and tailored to a particular user's operational problem. It is envisioned that personnel, requiring only knowledge of the scheduling domain, would be able to easily categorize resource (air crews, aircraft, cargo, fuel, etc.) scheduling problems via a user friendly interface, provide architectural interface requirements, and then automatically generate optimized, architecturally compatible scheduling algorithms that integrate with other components, as necessary, to provide highly reliable, responsive, and compliant end user scheduler applications. Generated schedulers must (1) be usable both in batch-oriented and continuous (i.e., incremental/evolutionary) mode with minimal perturbations of the evolving schedule, (2) provide a user with control over the tradeoff between runtime of the scheduling engine and the quality (e.g., minimization of cost, time, resources to accomplish a mission) of the schedule, and (3) provide a graphical data visualization capability to help users better understand a complex scheduling problem-solution set: the task data (i.e., the scheduling problem) and the schedule's resource utilization (i.e., the scheduler's solution).

Phase I: Describe the proposed concept in detail. Provide a prototype that demonstrates viability of the approach with respect to high risk aspects. Document results in a final technical report.

Phase II: Develop and demonstrate a generator of scheduling engines that addresses needs as indicated above. Demonstrate the prototype using a realistic, operationally significant scheduling problem. Provide a final technical report documenting the technology development and demonstration.

Dual Use Commercialization Potential: Scheduling of resources is a task that is prevalent in both the commercial (e.g., transportation) and military sectors. As a result, this technology has substantial dual-use potential and will impact the competitiveness and performance of the commercial sector as well as the military sector.

Related References: None

KEYWORDS: Resource Scheduler, Scheduling Engine, Multi-Resource, Automated Code Generation, Data Visualization

AF03-081 TITLE: Object-oriented Concurrent Distributed Engineering, Development, and Operations

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Weapons

ACQUISITION PROGRAM: Space and Missile Systems Center (SMC)

Objective: Develop and demonstrate distributed decision support environment technologies that support cross domain/cross discipline collaboration for concept development, acquisition, operations and logistical support of complex systems

Description: Distributed electronic collaboration is a crucial enabling technology for the 21st century and a change in the way of doing business that will have major implications for the commercial and defense sectors. The commercial marketplace is presently making greater use of concurrent engineering and development, product and process modeling, generic simulation techniques, simulation infrastructure, and off-the-shelf components for applications in selected manufacturing industries and for information systems. The defense sector lags in tailoring these technologies and applying them to the often unique challenges of weapon system acquisition – very long product life times and greater system of system complexity. The purpose of this research is to develop innovative technologies that can be used to implement a technical environment for the engineering, acquisition management, operations and logistics support for weapon systems or other complex electromechanical and information systems. World class companies in selected commercial industries, such as aircraft and automotive, have demonstrated initial successes in the creation of smaller systems with concurrent development at geographically dispersed locations and virtual integration via a wide-area network. For Air Force applications, the researcher should consider best of best development and acquisition practices and technologies and innovative methodologies that will permit the decomposition of complex defense systems into modular elements or objects that can be concurrently developed by multiple labs and contractors at geographically dispersed locations. Existing analysis, modeling and simulation, or hardware assets may be utilized so long as the individual elements have interfaces capable of communicating with others using common protocols. Virtual integration of the system – in simulation and in real hardware – should be possible over local-area and wide-area networks that permit comparison of alternative or competitive versions of the same system object via a dynamic configuration control mechanism. The researcher should consider technologies that support very high levels of operability, maintainability, reliability and safety for the assembled and deployed systems. Major functionality features include: standards (international/industry) based architecture, ability to integrate applications via open application programming interface, customizable software agents, dynamic object modeling, and core services for collaboration. Major collaboration features include: chat, shared applications, video and audio conferencing, document management, knowledge-driven workflow, web-based forms, and a user configurable portal interface. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations, be platform independent, and comply with industry or international standards when feasible.

Phase I: Phase I activity shall include: 1) specification of a dual use scaleable distributed collaborative decision support environment for complex electromechanical and information systems, 2) development of a design concept to assess, simulate, integrate and present decision support information across the product life cycle (concept development, acquisition, operations and logistical support) of complex systems in Phase II, and 3) a proof-of-feasibility demonstration of key enabling concepts that integrate several system objects in real-time from geographically dispersed locations.

Phase II: The researcher shall design, develop, and demonstrate a distributed engineering and acquisition decision support environment with transition capabilities for operations and logistics. The researcher shall also detail the plan for the Phase III effort.

Dual Use Commercialization Potential: The desired product of Phase III is a robust, off-the-shelf distributed decision support environment for use in defense and commercial product planning, development, and manufacturing. Distributed Collaborative Decision Support technology is applicable to financial and manufacturing industries, biotechnology, healthcare, transportation, communication and information systems. The aircraft and automotive industries have demonstrated the success of integrated computer assisted design with supporting modeling and simulation to bring products to market quickly.

Related References:

1. Deshmukh, et al, “Multiagent Design Architecture for Intelligent Synthesis Environment,” AIAA Journal, Vol. 38, No. 2, March-April, 2001

2. McQuay, William, “Put a Virtual Prototype on Your Desktop,” Program Manager Magazine, 94-99, September-October 1997. http://www.dau.mil/pubs/pdf/pmpdf97/ms_desk.pdf.

3. McQuay, William, “Distributed Collaborative Environments for the 21st Century Laboratory”, 2001 Aerospace Conference, March 2001. http://www.collaborationforum.org/collaboration/publications/F45_1.pdf

4. Sriram, et al, “An Object-Oriented Representation for Product and Design Processes,” Journal of CAD, Vol. 30, No. 7, 1998

5. Valenti, M., “Re-engineering Aerospace Design,” Mechanical Engineering, Vol. 120, January 1998

KEYWORDS: Distributed Systems Engineering, Virtual Life Cycle, Virtual Acquisition, Affordability

AF03-082 TITLE: <u>TCP/IP Addressing Concepts for Deployed Users</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Space (SP)

Objective: Develop TCP/IP (Transmission Control Protocol/Internet Protocol) concepts and algorithms that provide "net-Centric" connectivity through SATCOM systems.

Description: As the military battlefield increasingly enters the information age, new protocols are needed to optimize on-orbit military satellite communications assets to meet warfighter requirements. In order to adapt TCP/IP protocols for military satellite communications use, solutions must be found to overcome the differences associated with timing and QoS (Quality of Service) between satellite and terrestrial networks. These differences include signal latency resulting from large distances associated with satellite geosynchronous orbits and crosslinks; increased packet losses due to higher satellite transmission bit error rates; asymmetric bandwidths between satellite uplinks, downlinks and crosslinks; and addressing and security measures required to protect end user geographic location from disclosure. In light of these differences, highly innovative solutions are needed to broach the chasm between the two types of networks, and consideration should be given to innovative solutions including, stream control transmission protocol and autosophy transmission and data compression.

Phase I: Design a ground-based solution to overcome problems in satellite use of TCP/IP. Architectural design should consider Net-Centric connectivity, with consideration given to data compression techniques, forward error correction, caching or proxies, and transaction batching. In concert with the Air Force, Select a commonly used baseband device and design an interface paying special attention to the inherent vulnerability of addressing relative to physical location of the user.

Phase II: Using a software test bed that simulates satellite delays, bit-error-rates, asymmetric bandwidths, and end user geographic information, validate the operation of the protocols, including a pseudo interface for military like crypto equipment for an end-to-end solution. Interoperability with commercial systems is encouraged to optimize all space based communication assets.

Dual Use Commercialization Potential: Improvements in TCP/IP performance will benefit both the DoD and commercial satellite industries. Commercial industry shares an interest with DoD in the use of mobile platforms for satellite IP based Internet services, and there is potential for 3G (third generation wireless format) applications. Delivery of tested architectural solution is paramount in overcoming inherent TCP/IP issues for geosynchronous communication satellite systems.

Related References:
1. Allman, M., NASA Lewis/Sterling Software, Glover D, NASA Lewis, Sanchez L., BBN, "Enhancing TCP Over Satellite Channels", January 1999,

2. Holtz, K., Holtz, E., Kaliensky, D., "Autosophy Information Theory provides lossless data and video compression based on the data content"

3. Woods, L., "Internetworking with Satellite Constellations", February 2001

KEYWORDS: TCP/IP, control protocol, Latency reduction, Data compression , Satellite IP

AF03-083 TITLE: GPS Spaceborne High Efficiency, Jam-resistant Satellite Crosslinks

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop architecture for and prototype elements of a radio frequency and/or optical based GPS satellite cross-link system that is jam-resistant (friendly and hostile), with high reliability. Any radio frequency system developed must be within the frequency allocation designated for inter-satellite communication and also provide for backward compatibility and allow for graceful transition.

Description: Future GPS satellite cross-links need to be at a frequency allocated for inter-satellite services or in the optical portion of the electro-magnetic spectrum. There are two types of system architectures the GPS III satellite system has under consideration: a GPS stand-alone satellite constellation or GPS with augmentation. GPS stand-alone means that GPS satellites will not be in communication with other satellite or ground systems that are not dedicated to GPS. For the second architecture (GPS with augmentation), communication with other space systems is a possibility. Therefore, cross-links out of GPS satellite orbit planes can be considered – medium earth orbit (MEO), geosynchronous earth orbit (GEO), or other navigation system near the GPS orbit plane. One of the objectives of GPS III is to allow remote commanding/telemetry/ranging functions over a cross-link system. Data transfer and navigation messaging in conjunction with limited communications of up to a megabit /sec data transfer rate is desired. Use of the Tactical Data Relay Satellite System (TDRSS) or a combination of cross-links/TDRSS can also be considered. The main criteria for cross-links, is that they are to be robust and incorporate good anti-jam techniques that allow for operation in a noisy RF environment. An RF or laser cross-link or a hybrid RF/optical system can be considered. Note that for a RF cross-link system the frequencies selected must be in the allocated spectrum for inter-satellite use. The cost of any potential architecture should be considered as one of the feasibility factors for the proposed architecture.

Phase I: This phase will cover the research and design synthesis of possible cross-link architecture(s) and candidate technologies: RF or laser. System parameters, such as range, transmitter characteristics, coding algorithms, modulation type, and receiver characteristics may be defined at a general level. System performance parameters should be stated in a general level, with early definition of risks for each type of cross-link architecture. The Phase 1 deliverable is a report and an overview presentation of the results of the cross-link research and design synthesis. Emphasis should be placed on novel cross-link technology that may be mature enough to be available in 2010.

Phase II: Based upon the results of Phase I, the contractor will develop a more detailed system level design for the selected architecture and prototype selected high-risk components of that architecture. The deliverables will require more in-depth technical content, a technology forecast, and a refinement of the cross-link architecture(s). As a minimum the following will be considered: (1) candidate components (i.e. transmitters and receiver technology, modulation techniques, coding algorithms, high power amplifiers, etc.); (2) state of technology development; (3) system performance parameters (some of the desired performance will be supplied); (4) risk assessment. (5) Perform simulation analysis and modeling for the proposed architectures. The Phase II deliverables will be a report and presentation of the results.

Dual Use Commercialization Potential: Although GPS is considered a military space system; it is quickly becoming dual civil/military system. The integrity of the GPS system, in providing navigation is key. Therefore, any cross-link system implemented by GPS must be very reliable as safety-of-life functions are becoming more dependent on GPS. Commercial space system are always looking at highly reliable cross link system architecture, and GPS could lead the way in development of a highly reliable cross link system technology applicable for technology transfer.

Phase III would concentrate on maturing a system architecture via identification/demonstration of high-risk technologies identified on the architecture technology path. The objective is a highly reliable cross-link system. This could cover items such as manufacturing techniques and accelerated lab-to-factory plans. System performance parameters would be refined to create this highly reliable cross-link, and a technology pathway that the GPS JPO can activate to achieve the end goal.

GPS SV-to-SV Interface Requirements Specification, IRS-GPS-SV/SV-05.

KEYWORDS: Jam resistant, Coding algorithms, EHF RF technology, Satellite networks, Frequency hopping, Spread spectrum,. RF technology

AF03-084 TITLE: Data Fusion Algorithms Development

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: Space (SP)

Objective: Develop data fusion algorithms to enhance sensors' target identification and target location prediction capability

Description: Studies revealed that no single system would be able to satisfy all of intelligence, surveillance and reconnaissance (ISR) mission requirements. Technological advances in sensor areas for military and commercial applications have developed additional new systems to support ISR missions such as high-resolution multispectral (MSI) and hyperspectral (HSI) sensors. Spectral sensors promise the capability for anomaly detection and material ID. As the number of sensors becomes more available in the battlespace, an integrated system of all available ground, air, and space-based collecting systems should be considered to provide more accurate target information to the warfighter. This is especially true for situations involving the detection and tracking of very important targets or assets that may be traveling in and out of "visually denied areas" To overcome this difficulty, a collection system's unique capabilities should be fused with other system data to produce refined and enhanced utility information. This topic calls for the development of a novel data fusion algorithm, which allows for the ability to track and detect vehicles coming in and out of hide. The algorithm should utilize multiple ISR systems such as multi/hyperspectral and moving target indicator (MTI) data as well as make sure that the data is combined in a timely manner without distortions. The effort shall include the following figure of merits: a) develop strategies how to fuse spectral and SAR information into a common base, b) develop strategies for comparing results of fused versus raw data, c) develop strategies how to best adapt the fusion algorithm, and d) develop strategies how to select the data sources to be fused.

Phase I: Develop multi-sensor fusion requirements and strategies that involve MSI, HSI, and MTI data types for ground, air, and space-based collecting systems. Investigate and assess existing fusion algorithms' performance including both optical and radar systems, and identify its deficiencies. Identify any new fusion algorithms that are needed. Define Phase II fusion model development, implementation, and demonstration plan.

Phase II: Develop a prototype fusion system for the identification and tracking of vehicles, and materials using MSI, HSI and MTI data types. Develop a fusion simulator to simulate and fuse different data sources at different command and control (C2) nodes in order to analyze the effectiveness of the fusion strategies developed.

Dual Use Commercialization Potential: In addition to DoD applications, data fusion algorithms and strategies for detection and tracking of materials are expected to have numerous commercial applications, e.g., weather monitoring, air traffic control monitoring, drug interdiction, pollution monitoring, natural disaster assessment, search and rescue, natural resource management, forestry, forest fire prediction and assessment., and tracking of pollutants.

Related References:

1. Enhanced All-Source Fusion, Air Force Research Laboratory's 2000 Success Stories Book, 27 August 2001

2. Strategy Master Plan for FY02 and Beyond, Air Force Space Command, 9 Feb 2000

KEYWORDS: Intelligence, Surveillance and Reconnaissance, Fusion, Optical System, RF System, Multispectral, Hyperspectral,

AF03-085 TITLE: Passive Communication Options for Miniature Satellites

TECHNOLOGY AREAS: Information Systems, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop passive optical communication options to support miniature satellite communications.

Description: Technological advances in miniature satellites will usher in a new paradigm for space operations in the future. Communication with miniature satellites is essential and can take place in various ways such as wide or narrow beam RF or optical. The data transmission could be accomplished by modulating passive corner reflectors or by other more advanced means such as a powered retroreflecting device which also provides amplification of the return signal. This topic calls for development of passive optical communication options in low earth orbit using retroreflective techniques ranging from a simple corner reflector to more sophisticated concepts such as an optically pumped gain medium which returns an amplified, remodulated signal back to its source. Success of this technology will enable a variety of military and civilian missions employing low cost miniature satellites which also may exploit new technologies such as microelectromechanical systems (MEMS) and micromachining. The pay-off is extremely low power communications which are also difficult to intercept and exploit.

Phase I: Assess the state of the art of optical pointing and link acquisition using various retroreflective (pointing and acquisition without the use of mechanical beam steering) or functionally similar techniques, and select the workable approaches that can be demonstrated on a flight in Phase II if flight sponsorship is available. Suitable hardware that can be integrated aboard an existing satellites such as those sponsored by DARPA should be identified and samples acquired during the Phase I. Develop a Phase II plan including a preliminary design, and bench test one or more candidate techniques that can lead to reliable and successful on-orbit operations. Additionally, the Space Experiments Board should be contacted to obtain a possible future flight sponsorship.

Phase II: Design and fabricate a prototype for space flight test during this phase. If the planned test flight can meet the shuttle schedule, the prototype should be designed and installed on DARPA satellites, and flown off the shuttle in low cost space experiments to test the tracking and acquisition performance and explore possible new approaches to the design, including the incorporation of new technologies (ie. MEMS and micro-opto-electromechanical (MOEMS) to provide the modulation function) that might not be included in the first phase of the design. If the shuttle flight is not available, a ground test plan is needed as a backup.

Dual Use Commercialization Potential: The technology developed is expected to increase the utility of miniature satellites to DoD, civil and commercial applications. Phase III could be an advanced prototype demonstration of practical on-board passive optical communication, compatible with the size, power, and maneuvering capability of miniature satellites.

Related References:

1. S. W. Janson, H. Helvajian, E.Y. Robinson, "The Concept of 'Nanosatellite' for Revolutionary Low Cost Space System", The Aerospace Corporation, Prcedgs of the 44th IAF Congress, Graz, Austria, Oct 1993

2. H. Helvajian and E. Y. Robinson, "Micro- and Nanotechnology for Space Systems: An Initial Evaluation", The Aerospace Corporation, 31 March 1993

3. E. Y. Robinson, "ASIM and Nanosatellite Concepts for Space,sytems,Subsystems, and Architectures", The Aerospace Corporation, 1995

4. Robinson, E. Y., Helvajian, H., and Janson, S.W, "Small and Smaller: The World of MNT", Aerospace America, pp 26-32, September 1996

5. Robinson, E. Y., Helvajian, H., and Janson, S.W, "Big Benefits from Tiny Technologies", Aerospace America, pp 38-43, October 1996

KEYWORDS: corner reflectors, Microelectromechanical systems, Micromachining, Microopto-electromechanical systems

AF03-086 TITLE: <u>Hyperspectral Visualization & Spectral Exploitation (HyperVISE)</u>

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: Space (SP)

Objective: Develop an analyst oriented software tool for visualizing hyperspectral data and performing hyperspectral signature analysis for exploitation and product generation purposes.

Description: Hyperspectral imaging is a relatively new technology that can extend the capabilities of traditional electro-optical imaging systems by providing more detailed spectral signatures to support improved procedures and accuracy for target detection and material identification. These include a variety of both military and civilian applications including detecting the use of camouflage, concealment and deception (CC&D) targets, development and deployment of nuclear, biological, and chemical (NBC) weapons, as well as agricultural, environmental and geological assessments.

The capability to recognize and differentiate materials and agents using appropriate spectral signatures is a key to the success of hyperspectral sensing and exploitation. In addition to spectral analysis techniques, selecting the optimal bands for viewing the hyperspectral data is necessary to visualize those discrete regions in the electromagnetic spectrum where distinguishable material characteristics can be seen. Historically, hyperspectral processing has been accomplished by imaging research scientists using complex procedures and laboratory derived signature databases to match known signatures of known materials to extracted signatures for identification purposes. It is not unusual for this type of processing to take hours. Typically these signature databases have been sensor specific so each hyperspectral sensor had its own database of signatures. Spectral signature databases should be more generic in nature and be applicable to a family of sensor systems. Where, systems covering similar spectral regions could fall into the same family, although the number of bands in each system might be different. Spectral signatures should also be less pristine than laboratory derived ones and be more in tune with field conditions. Innovative procedures for accounting for dusts, smokes and other intervening agents encountered in battlefield situations need to be taken into consideration. Moreover, software environments for processing hyperspectral data should be analyst oriented and the exploitation tools within these environments should be very timely, easy to use and not require any special or complex knowledge to run. Extrapolation and interpolation procedures need to be investigated and developed to allow signatures from one hyperspectral sensor to be applied to other sensors within the same family of systems. Spectral signatures should be relevant to a broad range of imaging and field conditions to create a typical or average signature representation for a particular target or material. Automated band selection should be possible to facilitate the desired visualization requirements of the analyst. The analyst should be able to automatically display band combinations that depict natural color, color infrared, or other various renditions without having to recall which bands for which sensors produce these effects. It should also be possible to perform the same type of automated band selection for highlighting materials of interest such as camouflage, chemical agents or to help assess conditions for trafficability areas, geological surveys or environmental assessments. Displaying the right bands that support visual recognition can help curb the need for processing. Functions to shorten processing time, such as cropping out hyper-cubes, selecting out multiple columns of data to be processed and creating band-reduced images should also be included. Coupled and integrated with the hyperspectral capabilities should be a set of standard functions to support geo-positioning, mensuration, graphic annotations, overlays, product generation and other conventional image processing and exploitation tasks. There is a need for a cost effective, point and click, easy to use hyperspectral visualization and spectral exploitation tool for both Government and commercial applications.

Requirements to utilize and exploit hyperspectral data will increase in size as new sensors become available for both Government and commercial applications. This topic calls for the development of software tools to support visualization and signature analysis. Mathematical procedures for the characterization of spectral signatures will also be considered. This technology will save money and time, and enhance the utility of hyperspectral imaging to support the warfighter and the private sector.

Phase I: Define and design a hyperspectral visualization and spectral exploitation architecture to support timely, reliable and easy to use analysis functions. Demonstrational prototypes shall be constructed to support the development and implementation strategy for the architecture and functions within it. A Phase II Development and Demonstration Plan shall be included.

Phase II: Develop the Hyperspectral Visualization and Spectral Exploitation capability and demonstrate its performance using actual representative datasets. Demonstrations shall address a variety of Government and commercial applications. The scope of each demonstration shall include exploitation scenarios that demonstrate the utility and timeliness of the developed functions and procedures. The acquisition of the data sets to support the demonstrations shall be the primary responsibility of the developer. The Government shall provide assistance in the acquisition of data.

Phase III Dual Use Applications: In addition to supporting Government hyperspectral sensing and exploitation requirements, this technology should also benefit commercial and private sectors by providing a cost effective capability that was virtually unavailable to individuals or small concerns.

Related References:
1. Strategy Master Plan for FY02 and Beyond, Air Force Space Command, 9 Feb 2000
2. A predictive Methodology for the Effects of Chemical Agents on Materials, A01-056, Army SBIR Topic
3. Soil Prediction Modeling, A01-1432, Army SBIR topic

KEYWORDS: Hyperspectral Imaging, Spectral Signature Analysis, Image Processing and Exploitation, Nuclear, Biological, and Chemical (NBC), Camouflage, Concealment and Deception (CC&D)

AF03-087 TITLE: Low Loss/Low Cost Phase Shifters

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Design/prototype low loss phase shifter for phased arrays that significantly lowers the production cost for needed communication antennas.

Description: Phased arrays for communication antennas offer tremendous benefits for enabling high data rate connectivity. They have many advantages over the traditional antenna concepts, including graceful degradation, low profile, and electronic beam steering. The traditional phased array includes radiating elements followed by an active module. This module typically includes amplification and a phase shifter for setting the beam position. Due to the cost of the phased array it has not been aggressively used in communication systems. The array cost drivers are the active components and associated housing for the active components.

One approach to lowering costs for the array is to look to innovative phase shifter designs. Typical phase shifters employed in phased arrays for communication applications have 6-10 dB of insertion loss. Low loss phase shifters would enable a reduction in the number of amplifiers required to compensate for phase shifter losses. For an array with 4000 elements, reducing the number of amplifiers from 4000 to 1000 offers a significant cost reduction in the overall array. In addition, lowering the cost of the phase shifter itself would be beneficial. This effort is to design a low loss, low cost phase shifter for use in 20 GHz receive arrays. The desired frequency band should cover both commercial and military frequencies, from 19.2 to 21.2 GHz. The phase shifter loss should not exceed 1 dB with a goal of 0.6 dB. The required number of bits is three. The chosen design should ultimately be based on a reliable device technology.

Phase I: Design and analyze a reliable, 3 bit phase shifter. Provide theoretical performance data across the frequency band 19.2 to 21.2 GHz including phase shift and insertion loss. Describe the production approach and provide projected costs.

Phase II: Fabricate a minimum of 10 prototype phase shifters. Characterize the performance over the frequency band and compare against theoretical performance. Demonstrate to AFRL program manager test procedure and measured results. Describe next generation modifications for improved performance. Document the results.

Dual Use Commercialization Potential: Arrays for LEO and MEO commercial systems plan to utilize low cost arrays. Low cost, low loss phase shifters is an enabling technology.

Related References:
1. Horowitz and Hill, "The Art Of Electronics", Cambridge University Press, 1989

2. Koul, Shiban K., Bhat, Barathi; "Microwave and Millimeter Wave Phase Shifters, Semiconductor and Delay Line Phase Shifters", Artech House, 1992

KEYWORDS: Phase shifters, true time delay, ferro-electrics, MEMS, MMIC, beam position

AF03-088 TITLE: V-band Traveling Wave Tube Amplifier

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Advance the state of the art of millimeter wave Traveling Wave Tube Amplifiers (TWTA)

Description: While the military's need for battlefield information is increasing by about an order of magnitude per decade, military satellite capacity is constrained by limited spectrum availability. Future access to additional spectrum hinges on developing the technology to operate beyond the Ka-band. The objective of this topic is to develop a lightweight, power efficient, compact, 70W or greater traveling wave tube capable of operating frequency range of 49 GHz and 52 GHz. Additional goals include capability to operate in a space environment, spurious suppression of at least –50 dBc (Decibels referenced to the carrier), saturated efficiency greater than 45%, and operating temperature range from –40 to +80 degrees C.

Phase I: Design a TWTA capable of operating within the frequency range of 49 GHz and 52 GHz. Using a suitable model, simulate the Traveling Wave Tube operating characteristics including operating frequency, output power. Develop a plan for building a prototype RF device.

Phase II: Fabricate a prototype of the phase I design. Characterize the operation appropriate including operating power, frequency of operation, noise performance and EMC (electromagnetic compatibility), saturation input level at which of the output signal distortion.

Dual Use Commercialization Potential: Commercial and military satellites are spectrum challenged and are likely to be moving into the high frequency bands at some point in the future.

Related References:

1. JohnT. Mendel, "Helix and Coupled-cavity Traveling Wave Tubes," Proc, IEEE, vol. 61, no. 3, March 1973, pp. 280-298.

2. O. Sauseng, A. E. Manoly and A. Hall, "Thermal Properties and Power Capability of Helix Structures for Millimeter Waves," Technical Digest, International Electron Devices Meeting, pp. 534-537.

3. T. J. Grant, R. Garcia and G. V. Miram, "Bonded grid electron gun for 95 GHz extended interaction amplifier," Technical Digest, 1983 International Electron Devices Meeting, pp. 141-143.

KEYWORDS: Radio Frequen, Monolithic Microwave, Integrated Circuit, Satellite, Solid State Power Amplifier, Traveling Wave Tube, Amplifier

AF03-089 TITLE: Improved Synthetic Aperture Radar Quality

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Command & Control (C2)

Objective: The objective of this research is to investigate methods of improving airborne surveillance platform SAR image quality with non-traditional compression and detection techniques to achieve high compression rates with minimal impact on quality.

Description: Current and future intelligence, surveillance, and reconnaissance platforms that exploit advanced SAR systems to identify critical targets will require new approaches for integrating sensor, computer, and target recognition technologies to support the technical and operational challenges that exist for these applications. The emerging high altitude endurance, Unmanned Air Vehicle platforms, the U2R/Advanced Synthetic Aperture Radar System (ASARS)-II, enhanced Joint Surveillance Target Attack Radar System (JSTARS) and other related systems will be capable of gathering very large amounts of high-resolution SAR imagery.

Enhanced SAR uses a step frequency approach for wide band image generation. Resultant image quality depends on the synthesis approach of combining the component images from different frequencies to obtain a high-resolution image. Each step of the SAR waveform is coherent. However, there is phase difference between each step. The quality of the resultant image depends on the estimation of phase between the overlapped band. Discontinuities in the band affect the quality of the generated image. The proposal should evaluate alternative synthesis filtering, autofocus, superesolution with emphasis on the throughput and computational aspects. Non-traditional data compression and image detection methodologies, such as wavelets, are of interest.

Phase I: Develop and demonstrate the features of the phase synthesis and auto focus algorithms. Process real data from surveillance platforms to demonstrate algorithm effectiveness.

Phase II: Continue algorithm development and characterize system performance with automatic target recognition.

Dual Use Commercialization Potential: The new algorithm developed under this effort will be directly applicable to the current and future advanced sensor systems (Joint STARS & Multi Platform – Radar Technology Program) as well as Homeland Defense and the FAA.

Related References:
1) JPEG 2000: Image Compression Fundamentals, Standards and Practice (Kluwer International Series in Engineering and Computer Science, Secs 642), by David S. Taubman and Michael W. Marcellin
2) Physical wavelets and radar, IEEE Antennas and Propagation Magazine, February, 1996.
3) Electronic Warfare and Weapon Systems Engineering Radar Handbook, http://ewhdbks.mugu.navy.mil/wavelet.htm.

KEYWORDS: Radar, Image Compression, Wavelets

AF03-090 TITLE: Multi-Intelligence (INT) Fusion to Augment Track Continuity and Provide ID

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Command & Control (C2)

Objective: Develop concepts and techniques for the fusion of Ground Moving Target Indicator (GMTI) and other intelligence sources to provide location and identification of ground moving vehicles.WARFIGHTER IMPACT: Positive identification and automatic continuous tracking of militarily significant ground targets.

Description: GMTI radar provides continuous wide area surveillance coverage and precision tracking of ground moving vehicles. GMTI trackers provide direction and velocity of ground moving vehicles but cannot provide identification of the vehicle. GMTI trackers also have trouble maintaining track of a single vehicle in dense vehicle environments, through complex vehicle movements, or over long periods of time. In fact, analysis has shown that the track lifetimes exhibited by current trackers against real data, do not adequately support the warfighter's goal of finding, fixing, tracking, targeting, and engaging, high value ground mobile targets. Feature aided tracking techniques are currently being researched as a solution to these problems and preliminary results have shown benefit. However, the performance of these techniques is also limited in situations where current trackers have difficulty (e.g. data loss due to terrain or foliage obscuration or platform turns, associating vehicles in dense target environments). These techniques do not provide positive ID of the targets as well. To overcome these deficiencies, the potential of other sensor and intelligence sources to augment GMTI trackers must be investigated. Therefore, the goals of this effort are to increase track duration of the ground moving vehicles and provide an identification of vehicles through the fusion of multi-int sources and GMTI. Innovative approaches and algorithms for the fusion of ground moving vehicle tracking and other intelligence sources are sought. The other intelligence sources to fuse with the GMTI includes: SIGINT (Signal Intelligence), IMINT (Imagery Intelligence), MASINT (Measurement and Signature Intelligence), and HUMINT (Human Intelligence). The research should consider approaches to real time multi-INT fusion and as well as non-real time fusion in which information is extracted from intelligence databases to provide a history of the vehicle(s) movement.

Phase I: The Phase I effort will conduct the research required to define the technologies and algorithms needed to fuse multiple data sources together in order to obtain an improved understanding of the ground moving environment. The application for this effort will be the fusion of multi-INT sources (GMTI, SIGINT, IMINT, MASINT, HUMINT) to locate and identify ground-moving vehicles. The Phase I research will identify the critical technology challenges and define Phase II. Phase I risk reduction experiments/simulations will be conducted to demonstrate the feasibility of the proposed Phase II approach.

Phase II: Develop software algorithms to implement the approach developed in Phase I. The Phase II effort will implement and demonstrate prototype of the multi-INT fusion techniques and algorithms defined in Phase I. A commercialization plan may be developed.

Dual Use Commercialization Potential: This technology could be used in a broad range of military and civilian applications where automatic surveillance, tracking, and identification are necessary. Known private sector application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS) traffic control, drug enforcement, transportation systems, and security in industrial facilities. Highway safety, in particular, is a natural fit for this technology. All weather radar-based automated tracking systems can be developed which track and predict future movement of objects and then alert drivers to possible dangerous situations and recommend courses of action.

Related References: none

KEYWORDS: Ground Moving Target Indicator, track continuity, fusion, continuous tracking

AF03-091   TITLE: <u>Space Based Radar (SBR) Space Time Adaptive Processing (STAP)</u>

TECHNOLOGY AREAS: Information Systems, Space Platforms

ACQUISITION PROGRAM: Command & Control (C2)

DESCRIPTION: Space Based Radars can provide a wide area surveillance including areas denied to airborne platforms. These systems typically would require large reflector antennas fed by phased array lenses. The SBR will operate in severe countermeasures environment comprised of numerous theater wide jammers. Advanced signal processing will be required to detect small and slow moving targets in presence of severe ground clutter and interference. Most research conducted on signal processing emphasizes low earth orbit active phased array systems. The emerging capabilities of STAP promise to fulfill the stringent requirements of SBR. However, no single STAP algorithm is optimal in all interference scenarios therefore innovative GMTI techniques particularly applicable to medium earth orbit based SBR environment must be explored. The computer modeling and simulation tool, which can accurately evaluate the potential of the different STAP approaches, will be developed.

PHASE I: Perform an initial analysis of medium earth orbits SBR concepts. Investigate innovative STAP architectures to achieve high detection performance and low false alarm rates.

PHASE II: Complete the design initiated in Phase 1. The design should include coverage analysis, range analysis, radar waveform selection, antenna specification, clutter model and mathematical formulation of STAP signal processing algorithms. Implement a computer simulation model of the developed design.

PHASE III: Dual Use Applications: The computer simulation model is applicable to variety of military and civilian applications, which includes SBR, airborne surveillance radars, anti-drug surveillance systems, and communication systems.

Related References:
1. J. Ward, “Space-Time Adaptive Processing for Airborne Radar”, Tech. Rep. F19628-95-C-0002, MIT Lincoln Laboratory, December 1994.

2. H. Wang, “Space-Time Adaptive Processing for Airborne Radar”, in Digital Signal Processing Handbook, V. Madisetti and Williams eds., CRC Press 1997.

3. R. Adve, P. Antonik, W. Baldygo, C. Capraro, G. Capraro, T. Hale, R Schneible, and Wicks,“Knowledge-Base Application to Ground Moving Target Detection”, Technical Report, AFRL-SN-RS-TR-2001-185, September 2001.

KEYWORDS: STAP, GMTI, monostatic SBR, radar clutter, jamming

AF03-092 TITLE: Space Based Radar (SBR) Bistatic Space Time Adaptive Processing (STAP)

TECHNOLOGY AREAS: Information Systems, Sensors, Space Platforms

ACQUISITION PROGRAM: Command & Control (C2)

DESCRIPTION: Bistatic SBR concepts are considered for surveillance of air and ground targets because of their global filed of regard. Bistatic operation can also provide covert observation, increased survivability and larger aperture than monostatic systems. Typically large reflector antennas based on satellites in medium earth orbit or geosynchronous earth orbit (MEO/GEO) provide the illumination and phased array antennas deployed in low earth orbit (LEO) or on airborne platforms are used for reception. The bistatic SBR will operate in severe clutter and countermeasures environment comprised of numerous theater wide jammers. Advanced signal processing is required to mitigate the interference and enhance the detection of small and slow moving targets. Most of the research conducted emphasizes low earth orbit monostatic active phased array systems. The emerging STAP capabilities promise to provide better GMTI performance and improved interference rejection than non-adaptive techniques. However, no STAP algorithm is optimal for all interference scenarios and analytical results indicate that bistatic STAP performance will degrade more than in monostatic scenarios. Investigation of innovative STAP algorithms specifically pertinent to the bistatic MEO/GEO is required. A computer modeling and simulation tool, which can accurately evaluate the potential of bistatic STAP, will be developed.

PHASE 1: Perform an initial analysis of bistatic SBR concepts. Investigate innovative bistatic STAP architectures to achieve high detection performance and low false alarm rates.

PHASE 2: Complete the design initiated in Phase 1. The design should include coverage analysis, range analysis, radar waveform selection, antenna specification, clutter model and mathematical formulation of STAP signal processing algorithms. Implement a computer simulation model of the developed design.

PHASE 3 DUAL USE APPLICATIONS: The computer simulation model is applicable to variety of military and civilian applications, which includes SBR, airborne surveillance systems, anti-drug surveillance systems, and communication systems.

Related References:

1. G.L. Guttrich, W.E. Sievers, and N.M.Tomljanovich, "Wide Area Surveillance Concepts Based On Geosynchronous Illumination and Bistatic Unmanned Airborne Vehicles or Satellite Reception", Proceedings of the 1997 IEEE National Radar Conference, p.126-31, 13-15 May 1997.

2. B. Himed et al, "Bistatic STAP Performance Analysis in Radar Applications", Proc. IEEE 2001 National Radar Conference, Atlanta, Georgia, May 2001.

3. B. Himed, "Bistatic STAP in Spaceborne Applications", Proc. Workshop on Remote Sensing by Low-Frequency Radars", Naples, Italy, September 2001.

KEYWORDS: STAP, GMTI, Bistatic SBR, radar clutter, jamming

AF03-094 TITLE: Innovative Information System Technologies

TECHNOLOGY AREAS: Information Systems

Objective: Develop innovative information technologies for enhancing the performance, availability, and affordability of C4ISR systems/subsystems.

Description: Proposals may address any aspect of information pervasive technologies not specifically covered by other SBIR topics. Interest areas are: 1. Global Awareness. Entails the affordable operational capability (local to

global) for all personnel to understand militarily relevant situations on a consistent basis with the precision needed to accomplish the mission. Areas include:
a) Information exploitation. Includes hyperspectral imaging, video, text, and signals;
b) Information fusion. Seeks to accurately perform object refinement, situation/impact/process assessment/correlation, identify current/future threats, ability to adapt to new patterns/environmental situations; and,
c) Information understanding. Seeks to develop distributed, heterogeneous data/information systems to capture from all sources including text, data of any type, worldwide web, and the ability to reason over the data and learn the intricacies of the information supporting the warfighter needs. Capabilities include analytical tools/techniques for knowledge capture, management, and automated reasoning over the captured knowledge.

1. Dynamic Planning and Execution. Concentrates on the aerospace commander's ability to rapidly acquire and exploit superior, consistent knowledge of the battlespace through a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligent information specialists. Areas include:
a) Next Generation Coalition C2. Seeks to develop scalable/minimal footprint C2 technologies so planning staffs can account for the differing influences of all members of a coalition force; including differing control centers, military Rules of Engagement, multi-level security, cultures and doctrine in a naturally expressive and timely manner;
b) C2 Decision Support. Seeks to provide planners/decision-makers with the ability to view, analyze, and understand the vast amounts of information available from C4ISR systems. Collaboration, simulation and visualization, processes/tools are necessary for the integration of heterogeneous information systems and support for autonomous and self-teaming collaborative software processes; and,
c) Dynamic Execution. Seeks to provide the ability to rapidly respond to any crisis or situation, anywhere in the world. Covers campaign assessment, effects based operations, planning, scheduling and wargaming technologies.

1. Global Information Enterprise. Ability to interconnect all Air Force members via an adaptable/scalable netted communication/information system, available anywhere, at any time, and for any task/mission. Provides connectivity and networking for information users on a global scale, as well as the technologies that protect those capabilities. Areas include:
a) Aerospace Connectivity. Extends the C4ISR information architecture, including sensor-to-decision maker-to-shooter concepts, integration of space assets, wideband airborne connectivity, communication relays/switching nodes from platforms, theater information grids, assured communications links, and incorporation of airborne C2 to create a robust, seamless near real-time information in-theater environment with global reachback;
b) Information Assurance. Seeks to protect against corruption, exploitation, and destruction of friendly information systems (including wireless); ensure confidentiality, integrity, and availability of systems; integrate actions (offense, defense) to ensure an uninterrupted information flow;
c) Networking. Seeks to develop and integrate information-related technologies for information system management, enterprise management, adaptive Quality of Service, assured communications, and distributed computing; and,
d) Information Systems. Seeks the development/integration of information processing and computing technologies for distributed, survivable, and fault tolerant computing. Addresses high-performance and adaptive computing, new models for computing, and architectures such as bio- and quantum computing.

Phase I: Provide a report describing the proposed concept in detail and show its viability and feasibility.

Phase II: Fabricate and demonstrate a prototype device, subsystem, or software program.

Dual Use Commercialization Potential: Many Information Technologies have substantial dual-use potential and will impact competitiveness
and performance of the commercial sector as well as the military sector. All solutions proposed
must have potential for use/application in the commercial as well as civil/military sector, and
potential commercial applications must be discussed in the proposal.

Related References: none

KEYWORDS: Information Technology, C4ISR, Global Awareness, Dynamic Planning and Execution, Global, Information Enterprise, Fusion, Networking

AF03-095 TITLE: Cross-domain user identity and credential management

TECHNOLOGY AREAS: Information Systems

Objective: Investigate and develop a capability enabling the management and exchange of unique user identities and associated credentials across organizational and trust boundaries.

Description: Current mechanisms for cross-domain management of user identities and the exchange of associated cryptographic user credentials do not provide effective support for the establishment of unique user identities across organizational boundaries. Tools are needed to help manage the coordination of this "namespace" data, such that unique user identities can be established and maintained despite the arrival and departure of organizations and individuals in joint and multinational operations. Currently, organizational entities maintain namespaces which may be internally consistent, but when combined with the namespaces of other organizations, could produce conflicts in terms of the content, structure, and uniqueness of the identity data. Establishment of unique user identity, and associated privileges, is the foundation of all other information security mechanisms. For example, identity serves as the basis for authentication, which in turn, enables access control and supports auditing. Some type of automated, or semi-automated, approach is needed to enable information system managers to effectively deal with the rapid consolidation and turnover of personnel within mission-specific force packages, which are the hallmark of current quick-response military employment scenarios. Without such a capability, the namespace identity management process can quickly become an overwhelmingly complex and difficult task, thereby compromising the effectiveness, flexibility, and security of operational military forces. This process is often further complicated by issues of trust, and differences in technical protocols, employed by the constituent organizational entities that may be called upon to form combined military capabilities.

Phase I: Investigate the dimensions of the problem space. Use the knowledge gained to assess the extent to which currently available commercial technologies for Public Key Infrastructure (PKI), directory services, and policy management can be leveraged toward the development of the desired capability. Develop an approach and a high-level design based on this assessment.

Phase II: Develop and implement a prototype providing the capability defined in Phase I.

Dual Use Commercialization Potential: The capability described above addresses a systemic need across all military services and operational commands to effectively manage user identity in the increasingly-automated information systems of the Department of Defense. On-going and future information system acquisitions rely on extensive use of "Web-enabled" and Internet-based technologies for increased flexibility, efficiency, and cost-effectiveness. However, these benefits will be difficult to realize without the type of capability described. Similarly, the commercial world is increasingly relying on the rapid formation of partnerships to take maximum advantage of the ever-changing business environment. Thus, although the military and commercial sectors are driven by different purposes, their challenges in information system management are very similar, enabling the capability described here to have broad applicability to both sectors.

References: none

KEYWORDS: Identity management, PKI, directory services, security policy.

AF03-096 TITLE: Force Templates for Assimilating Unit Infospheres

TECHNOLOGY AREAS: Information Systems

Objective: Investigate and develop mechanism(s) that enable the rapid assimilation of combat information systems within an Infosphere.

Description: To achieve maximum effectiveness, the constituent elements of our military forces are tailored for each operation. Likewise, we must be capable of rapidly interconnecting the combat information systems used by our military forces to exchange information across functional, service, and often national boundaries, with great flexibility and adaptability. The demands of supporting a fighting force that can rapidly deploy around the globe in support of widely varying operations dictate that the information environment be tailored just as the force structure is tailored.

There are two parts to tailoring the information environment: the first is a platform that provides information dissemination and management services; the second is a set of entities (operational military units and the organizations that support them) and their clients (specific individuals, information systems or applications) that provide and use the information. Force template technologies will enable entities to quickly and securely plug in to the platform and exchange information, thus forming an Infosphere.

We envision three categories of information that the force template could potentially provide the platform: necessary, desired, and speculative. Necessary information includes information that the entity says it needs to function within the theater, information that the entity can provide within the theater, constraints, and security information. Desired information includes indicators of the quality, reliability, integrity of an entity's information products (publications), mapping of specific personnel to operational roles, and characteristics of the entity (including: unit organizational chart, mission description, location, capabilities description, resource map and sub-entities). Speculative information might include ontologies describing the terminology and information organization utilized by the entity, system, or related domain.

The force templates should ensure:
- Visibility and control over inputs and outputs.
- Entities maintain control over what their clients are allowed to do through the force template infrastructure. Clients are authorized based on the status of the owning entity¡¦s force template.
- Dynamic changes are allowed after registration, allowing the force template to evolve during the mission. These changes may be initiated from a number of sources within the platform infrastructure.
- The integrity and consistency of each entity¡¦s force template is maintained.

Phase I: Define the structure and organization of Force Templates. Define a client application programming interface (API) to use the force templates. Define a process for creation and management of force templates.

Phase II: Develop and demonstrate a prototype system that is secure and that rapidly incorporates new force templates.

Dual Use Commercialization Potential: Military applications include incorporation into the Joint Battlespace Infosphere (JBI) to permit rapid assimilation of military units and systems into a deployed JBI [1]. Commercial application of force templates includes management of trading partner agreements (TPAs) in business-to-business (B2B) commerce [2].

Related References:
1. Building the Joint Battlespace Infosphere, Air Force Scientific Advisory Board Technical Report SAB-TR-99-02, http://www.sab.hq.af.mil/Archives/index.htm

2. The Business Integrator Journal, Summer 2001

KEYWORDS: Information Management, Force Templates, Joint Battlespace Infosphere

AF03-097 TITLE: Indications and Warnings for Homeland Defense

TECHNOLOGY AREAS: Information Systems, Materials/Processes

Objective: Development of innovative approaches to support Indications and Warnings (I&W) for Homeland Defense.

Description: The United States and its allies face a number of new and difficult security challenges in the future. While past threats came from other states and were primarily aimed at U.S. forces or allies overseas, new challenges --- such as the proliferation of missiles and weapons of mass destruction, terrorism, and attacks on our information infrastructure --- may well involve non-state actors and will directly affect security at home.

Indications and Warnings (I&W) methodology has been utilized to determine if enemy activities are cause for a heightened state of alert. The I&W analysis process is very analyst intensive. The indicators (or events) are usually selected based on historical analysis, and although a single event may appear insignificant, when it is analyzed in conjunction with other indictors it may become very significant. The problem is how to obtain, organize, and analyze the vast amount of data.

The amount of data available has become overwhelming. How do we bring this amount down to a manageable size? Many of the fine grain tools, like information extractors or natural language understanding systems are very processor intensive and also many of them require raw documents to perform their ranking and indexing. There is no way that these systems can handle the load today or even in the near future.

If this data could be reduced to a "manageable" size, the problem of correlating the data still is paramount. This becomes a data fusion related problem area. The Joint Directors of Laboratories (JDL) Subpanel on Data Fusion has defined Data Fusion as "a process dealing with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimates, and complete and timely assessments of situations and threats, and their significance. The process is characterized by continuous refinements of its estimates and assessments, and the evaluation of the need for additional sources, or modification of the process itself, to achieve improved results".

Specific areas of research within Indications and Warnings for Homeland Defense are:
1. Development of innovative approaches for data acquisition; that is searching the infosphere for relevant reports;
2. Novel approaches to Information Extraction for locating the useful information within the various reports (known and unknown terrorists, organizations, entities, activities, events, etc);
3. Strategies for information gathering and planning dealing with uncertain, incomplete and ambiguous data/information;
4. Novel approaches for inferring relationships amongst infosphere elements (known and unknown terrorists, organizations, entities, activities, events, etc);
5. Innovative approaches for determining the current (and future) threats/impacts.

Phase I: Develop an innovative approach to a subset of the Indications and Warnings area that directly supports Homeland Defense.

Phase II: Develop a prototype Indications and Warnings system based on the Phase I design. Demonstrate the developed Indications and Warnings prototype to prove feasibility for a Homeland Defense capability.

Dual Use Commercialization Potential: There are many dual use applications of Indications and Warnings techniques. For example in the law enforcement community, this research could be applied to counter narcotics arena. On the commercial side, this research is applicable to business intelligence, where companies attempt to determine what their competitors are doing by collecting and analyzing data available over the web.

References:
1. A. Steinberg, C. Bowman, F. White, "Revisions to the JDL Data Fusion Model", Proc. Of the SPIE Sensor Fusion: Architectures, Algorithms, and Applications III, pp 430-441, 1999.

2. E. Waltz and J. Llinas, "Multisensor Data Fusion", Artech House, 1990.

3. R. Antony, "Principles of Data Fusion Automation", Artech House, 1995.

4. D. Jurafsky and J. H. Morton, "Speech and Language Processing", Prentice Hall, NJ, 2000.

KEYWORDS: Information Fusion, Data Fusion, Indications & Warnings, Information Extraction, Information Discovery, Knowledge Discovery, Situation Assessment

AF03-098 TITLE: IA Technologies for Mobile Users

TECHNOLOGY AREAS: Information Systems

Objective: Design and demonstrate a means to implement end-to-end security between mobile and non-mobile voice and data wireless networks.

Description: Advances in mobile radio networks are making it possible to carry out tasks such as financial transactions, full motion video conferencing, geolocation based services, and, in the near future VoIP over a wireless network. What has not been achieved to date is the full spectrum information assurance that will be needed to protect the data flow, detect potential attackers, and respond in real time to these threats. Security and authentication in today's mobile devices is not adequate. This inadequacy is further complicated by the fact that most mobile networks include a substantial number of wireless devices, and the security associated with today's wireless networks is also lacking. The breaking of the wired equivalent privacy (WEP) protocol used to secure wireless local area networks (WLAN) is a good example.

In addition to data security issues, WLANs have a number of other vulnerabilities that can be addressed in novel ways. Physical layer techniques for protection, including low-probability of detection (LPD), low probability of intercept (LPI), low probability of exploitation (LPE), and anti-jam (AJ) waveforms need to be applied to low-cost WLANs. Also, physical layer detection and response methods that utilize advanced antenna technology, attacker local oscillator (LO) detection, etc., need to be integrated with WLAN driver software and network control center (NCC) facilities. In fact, there are opportunities for developing and/or improving protection, detection, and response technologies for WLANs at ALL seven layers of the Open System Interconnect (OSI) stack.

Mobile networks are also in their infancy with respect to information assurance. Whether wired or wireless, there are critical issues that need to be addressed in order to properly secure mobile networks. Issues include those associated with mobile IP, use of virtual private networks (VPN), etc.

This SBIR topic seeks to address the above issues in a mobile environment that includes both wired and wireless segments based on a mixture of commercial standards such as IEEE 802.11, Microsoft Windows CE, PalmOS, IPsec, X.509, etc.

Phase I: Develop overall system design that includes user authentication, secure transmission of authentication parameters and end to end security for fixed and wireless communications. Identify opportunities for including protection, detection, and response technologies at the various network layers of the system design.

Phase II: Develop and demonstrate a prototype system in a realistic environment. Conduct red-team testing to prove feasibility, interoperability, and robustness. Implement selected protection, detection, and response techniques to increase overall information assurance.

Dual Use Commercialization Potential: This system could be used in both military and commercial systems where authentication and secure voice and data communications are necessary.

Related References: Randall K. Nichols, Panos C. Lekkas; Wireless Security, Mcgaw-Hill Copyright 2002

KEYWORDS: VoIP, Biometrics, PKI, mobile IP

AF03-099 TITLE: Effects-Based Counter Terrorism Operations

TECHNOLOGY AREAS: Chemical/Bio Defense, Information Systems, Materials/Processes, Biomedical, Human Systems

Objective: Develop tools to plan, execute and assess effects-based counter terrorism operations which consider the behavioral influences on the enemy's political, military, economic, social, infrastructure and information systems.

Description: Recent advances in techniques in support of Effects-Based Operations (EBO) are resulting in methods for planning and assessing more efficient and effective military operations. The majority of current EBO research and development is focused on generating tools to support activities at the operational level of war. Methodologies are needed to address the application of EBO for planning and assessing counter terrorism missions at the strategic level of war. This initiative will investigate technology development to help plan and assess courses of action (COAs) that the United States and coalition forces could take to prevent and mitigate acts of aggression by terrorist organizations. Targeted end users for this technology are those engaged in strategy planning for counter terrorism missions including members of the intelligence community, the US State Department's Counter Terrorism Office, and the Office of Homeland Security. Resulting technology could be used both in times of crisis and non-crisis and is applicable to both military and civilian domains. The technical goals of this SBIR initiative are to 1.) Research the applicability of EBO concepts to counter terrorism in general and in support of operation Enduring Freedom; and 2.) To build an EBO decision support system to effectively plan, execute and assess antiterrorism campaigns.

This SBIR topic is aimed at strategy development and assessment technology for counter-terrorism. Strategy development technology is needed to generate effects-based COAs that relate the effects necessary to disrupt and destroy terrorist networks to those actions required to do so, such as denying terrorist financing, conducting psychological operations and destroying terrorist training camps. This will require research in the area of behavioral and adversary intent modeling. Techniques will have to address and predict how friendly actions against an enemy's PMESII (Political, Military, Economic, Social, Infrastructure and Information) systems will impact their behavior. Assessment technology is needed to assess potential COAs through analytical means, for example probability modeling. The vision is that together, the strategy development and assessment technologies are used to conduct tradeoffs and optimize COAs to prevent and mitigate terrorism. To generate an effects-based COA for combating terrorism, it is necessary to understand both friendly and adversary desired effects. Desired adversary effects are those effects that terrorists hope to achieve. They can be analyzed through an effects-based assessment of our own vulnerabilities from a terrorist perceived point of view. This denotes the terrorist's potential courses of action (COAs). United States and coalition COAs based on desired effects are then developed to counter and deny the potential terrorist actions. The success of operation Enduring Freedom depends on many national instruments of power that are outside the domain of current DoD analysis efforts. The Effects-Based Operations construct is sound and ideally suited for Enduring Freedom. Technology is needed to meet the vision of applying EBO to combat terrorism.

Phase I: Define and develop the required strategy development and assessment technology necessary to plan and assess effects-based COAs in support of counter terrorism. This phase will result in a concept of operations and operational architecture design outlining how EBO can be applied to counter terrorism in general and in support of Enduring Freedom. A software tool design and prototype will also be developed for a decision support system for planning, executing and assessing effects-based counter terrorism campaigns.

Phase II: Develop and demonstrate an operational software tool to enable the implementation of EBO for counter terrorism. The tool will evolve through testing and enhancement of the prototype generated in Phase 1.

Dual Use Commercialization Potential: There are many dual use applications of Effects-Based Operations and software to implement their use. Strategy development and assessment technology could be used to support planning and assessment of military operations other than war. Some specific examples include hurricane relief, peacekeeping, and solving electrical power demand problems (e.g., California recent crisis). Effects-based operations tools could also be applied to plan and assess best commercial business practices. EBO tools are applicable to non-crisis military and civilian applications.

References:
1. McCrabb, Maris, "Concept of Operations for Effects-Based Operations" http://www.if.afrl.af.mil/div/IFK/prda/prda-main.html.

2. US State Department Office of the Coordinator for Counter Terrorism web site, www.state.gov/www/global/terrorism

3. Deptula, Dave, Gen USAF, "Effects-Based Operations: Change in the Nature of Warfare" Defense and airpower series journal, aerospace education foundation 2001.

KEYWORDS: Effects, Effects-Based Operations, Counter Terrorism, Course of Action

AF03-100 TITLE: Multi-Organizational Collaboration and Decision Support for Emergency Preparedness

TECHNOLOGY AREAS: Chemical/Bio Defense, Information Systems, Human Systems

Objective: Develop information/human systems technologies to improve distributed collaborative decision support for emergency preparedness.

Description: Recent events have indicated the need for rapid decision making in compressed time cycles for emergency planning and evacuations of civilian populations. Within the commercial and government sectors, multiple organizations or divisions of global companies must jointly collaborate, assess dynamic situations, execute complex plans, and interpret terabytes of information that often is incomplete or conflicting. Readiness for emergency situations, including terrorist attacks, requires a complex ongoing process of situation assessment and awareness of a wide range of potential chemical, biological, radiation, nuclear or cyber threats from a multiplicity of world-wide social and cultural groups. The researcher shall develop and demonstrate innovative information and human systems technology to improve the assessment, integration, and presentation of decision quality information for improved decision support for emergency preparedness, anti-terrorism, and homeland defense. Special emphasis is placed on innovative utilization of intelligent agents, data mining, simulation, and collaborative technologies. Assessing the relative importance of various data may require human behavioral modeling of hypothetical threat groups working under a variety of scenarios. Due to the combinatorial complexity of the problem space, the researcher should consider higher, meta-data analysis of information sources, conceptual scenarios and kinds of threat group behavior. This concept-based, meta-data analysis may require modeling emotional personality structure, cultural artifacts and social norms of threat groups as well as their probable cognitive and conceptual thought processes. The researcher should consider the appropriate human factors technology for the presentation of the decision quality information to key decision makers in the organizations. Human-computer interface and advanced information infrastructure technologies could include innovative approaches such as multi-user information/knowledge walls, wireless handheld or tablet input devices, and virtual local area and personal networks. Since key stakeholders may be geographically dispersed, a distributed collaborative environment may be necessary to integrate and disseminate the relevant information to the right people in a timely manner. The researcher should consider logistical methodologies and measures of efficiency and effectiveness that describe the potential to enhance military or corporate emergency response to homeland threats. The researcher should consider metrics of algorithmic complexity similar to those used for detection and classification of targets that are difficult to see in dense clutter such as the number of computer operations and required communication bandwidths as well as probability of detection versus false alarm rates. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. Any graphical depiction and output should comply with industry or international standards, such as HTML, VRML, and graphics metafile images. Methodologies implementing the decision support environment should be open and standards based to support interfaces to other analysis and simulation and modeling tools.

Phase I: Phase I activity shall include: 1) specification of a scaleable distributed collaborative decision support environment, 2) development of a design concept to assess, integrate and present decision support information for emergency preparedness and homeland defense, and 3) a proof-of-feasibility demonstration of key enabling concepts.

Phase II: The researcher shall design, develop, and demonstrate a distributed emergency preparedness decision support environment. The researcher shall also detail the plan for Phase III effort.

Dual Use Commercialization Potential: The desired product of Phase III is a robust, off-the-shelf distributed decision support environment for use in defense and commercial emergency preparedness. The defense sector application includes homeland defense and emergency evacuation. For the commercial sector, Distributed Collaborative Decision Support technology is applicable to emergency preparedness and planning for manufacturing, healthcare, and transportation industries.

References:

1. Bora, Wyatt D., Peter A. Jedrysik, Jason A. Moore and Terrance A. Stedman, "Wireless Interaction for Large Screen Displays," 2001 HCI International Conference, Aug 2001.
http://collaborationforum.org/collaboration/publications/CDSEP/index.jsp

2. Collins, Joseph J. and Michael Horowitz, "Homeland Defense A Strategic Approach," Center for Strategic and International Studies, Washington, D.C., December 2000. http://www.csis.org/homeland/index.html.

3. Jedrysik, Peter A., Jason A. Moore, Terrance A. Stedman and Richard H. Sweed, "Interactive Displays for Command and Control," 2000 IEEE Aerospace Conference, Mar 2000.
http://ieeexplore.ieee.org/lpdocs/epic03/authors.htm?findtitle=jedrysik

4. McQuay, William K. "Distributed Collaborative Environments for the 21st Century Engineer," IEEE Proceedings of NAECON 2000, October 2000.
http://collaborationforum.org/collaboration/publications/CDSEP/index.jsp

5. Perlovsky, Leonid I. , "Emotions, Learning And Control," 14th IEEE International Symposium on Intelligent Control, Intelligent Systems & Semiotics, Cambridge, MA, September 15-17, 1999.
http://collaborationforum.org/collaboration/publications/CDSEP/index.jsp

KEYWORDS: collaborative environment, decision support, emergency preparedness, homeland defense, human behavior modeling

AF03-101 TITLE: Multi-Band Antenna Technology

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: Space (SP)

Objective: Develop a small, light-weight, multi-band antenna capable of operating within UHF, L-band (500 to 1500MHz) or Ka-band (17 to 31 GHz) suitable for communications on the move (COTM) for use by aircraft, man packable terminals and hand-held terminals (HHT).

Description: Mobile satellite-based communication is desirable to both commercial and military users. As antenna technologies, including ceramic embedded, fractal element, and conformal antennas evolve, the size of terminals and antennas has dramatically decreased over the last five years, enabling transportable terminals for use by the foot soldiers and also enabling integration of the
terminal and antenna into a variety of warfighting platforms, including aircraft and combat vehicles. The purpose of this topic is to adapt recent antenna technology innovations to COTM applications for small multi-band terminals for mobile satellite communications at UHF, L-band, and Ka-band.

Phase I: Design and Develop an antenna prototype that is capable of transmitting and receiving at either the UHF, L-band or Ka-band. The antenna must be compatible with one or more of the following platforms: aircraft terminals, manpackable terminals and/or HHT (hand held terminals) . This prototype should have both military and commercial potential. In addition to size, weight, and transportability, the antenna should be designed to minimize set up time with enhanced survivability.

Phase II: Fabricate antenna prototype and characterize operation including gain, bandwidth, operating frequency range, weight, and setup time.

Dual Use Commercialization Potential: As commercial mobile satellite industry matures, there will be a growing demand for smaller lightweight antennas and terminals in L and K-bands. A military and commercial partnership will benefit in meeting the requirements of communications on the move for both the military user and businessman. Provide to industry a prototype for commercial evaluation and production.

References: Adams, R., Abramo, R., Von Mueller, D., COMWIN Antenna Project: Fiscal Year 2001 Final Report, September 2001

KEYWORDS: Small antenna, Communications-on-the-move (COTM), EHF Antenna, Aircraft antenna, UHF Antenna, Terminal

AF03-103 TITLE: Gateway Interface for C4ISR Platforms and their Assets

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Command & Control (C2)

Objective: Design and build a JBI-like embedded software unit with Force Template software to support C4ISR platforms and their assets.

Description: The Joint Battlespace Infosphere (JBI) must establish and maintain collaborative linkages with responsible elements at all echelons within the command, control, communication, computers, intelligence, surveillance, and reconnaissance (C4ISR) system. Based upon publication and subscription of object-based information, the JBI is not intended to replace C4 Systems but to be the substrate for integrating the broad spectrum of C4ISR platforms and systems (collectively, clients). Therefore, it is essential that the JBI provide a flexible information object type structure that can be extended as needs evolve, and a common programming interface to enable new platform implementations without modification to existing clients. Force templates are electronic descriptions of entities that enable their rapid integration into a JBI. The reference below points out several promising technologies for a JBI architecture. Eventually, this program will provide JBI real-time situation awareness information in numerous mission areas. Therefore, the interfacing unit and application software developed must be totally compatible to the JBI and other gateways.

Phase I: Conduct a feasibility analysis and capability analysis of the approach proposed in this SBIR. Produce a preliminary design document for a gateway.

Phase II: Produce a detailed design for the JBI gateway. Develop and demonstrate a prototype gateway that can inter-operate with a currently available JBI core service implementation. The gateway should be consistent with latest JBI Common Core services API to ensure compatibility amongst a number of JBI core service implementations.

Dual Use Commercialization Potential: The results of this program will have opportunities to a wide range of applications. This pervasive technology not only applies to existing and future C4ISR platforms, but to commercial airlines for recording events, such as black box information, real-time cockpit voice recordings and constant updates on critical system status. The PEO/DAC Portfolios have many information gathering platforms. For example, the AFPEO/JA Command and Control Program Office supports the Combat Intel System (CIS), Command and Control Center III (ABCCC), and the Ground Theater Air Control System (GTACS). Another strong candidate is being developed in the ASC/CC Reconnaissance Programs Office (RPO) which is called the High Altitude Endurance (HAE) Unmanned Aerial Vehicle (UAV). Also, AFPEO/C2 has the JSTARS and ESC/CC is involved with Mission Planning and Information Warfare that includes AMC Command and Control Information Processing System (C2IPS) and Air Sovereignty Operations Center (ASOC). This technology can also be used in commercial and military space projects in order to satisfy the overall JBI network.

References: 1. "Building the Joint Battlespace Infosphere", Vol I, SAB-TR-99-02, par. 5.1.7).

KEYWORDS: Joint Battlespace Infosphere, Force Templates, Middleware

AF03-109 TITLE: Improved Protective Coatings for High Strength Steels

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: Significantly increase the lifespan of landing gear components by improving the performance of the protective coating. An improved environmentally compliant paint/coating system is needed that has increased impact damage resistance, adhesion, and ability to protect high strength steel components from corrosion.

Description: Development of an improved corrosion preventative system to protect high strength steels, in particular aircraft landing gear components, is needed. Aircraft have experienced costly landing gear failures that have been attributable to corrosion problems resulting from high levels of foreign object debris (FOD) impact damage. The poor abrasion/impact resistance of the protective coating exposes the substrate to environmental conditions conducive to corrosion. These failures put the aircrew, aircraft, cargo, and ground support personnel at significant risk and contribute to excessive maintenance downtime. Current 300M steel components have a coating system consisting of 3-6 mils cadmium plating, approximately 1 mil MIL-P-23377 T1 C2 epoxy primer, and approximately 2 mils MIL-C-83286 or 85875 polyurethane topcoat. New coating systems must also be easily and quickly repairable in the event of damage. Improved protective coating systems that eliminate the need for cadmium plating are of greatest interest.

Phase I: Demonstrate the feasibility of novel coating system materials and/or processes for corrosion protection of 300M and Aermet steel substrates under simulated exposure conditions. Key test parameters include resistance to mechanical damage (e.g., gravelometer, adhesion testing) and corrosion protection of mechanically damaged/undamaged samples (e.g., B-117 salt spray, Prohesion™, electrochemical methods). In addition, common coating performance tests (i.e., solvent resistance, flexibility, etc.) should be performed to maintain or exceed current system results.

Phase II: Further develop and optimize the coating system developed in the Phase I effort and demonstrate the performance improvements using the developed coating technology on aircraft systems. Further emphasis should be given to methods of improving environmental compliance, weight reduction, color/appearance, and non-destructive evaluation (NDE) of the steel substrate.

Dual Use Commercialization Potential: These protective coatings will have multiple uses for both military and commercial aircraft applications. In addition, any transportation or mechanical systems where steel is exposed to a corrosive enviroment will have applications for the coating system.

Related References:

1. Lee, E. U.; Waldman, J. "Corrosion of Aircraft Landing Steels", Nav. Eng. J. 1994, 106, 77-83.

2. Tucker, J. G. "Elastomeric Polyurethanes Used as Coatings in the Arduous Conditions of Severe Corrosion and Abrasion", Anti-Corrosion Methods and Materials 1986, 33, 10/13.

3. Osborne, J. H.; Blohowiak, K. Y.; Taylor, S. R.; Hunter, C.; Bierwagen, G. P.; Carlson, B.; Bernard, D.; Donley, M. S. "Testing and Evaluation of Non-Chromated Coating Systems for Aerospace Applications", Progress in Organic Coatings 2001, 41, 217-225.

4. Jones, D. A. Principles and Prevention of Corrosion; 2 ed.; Prentice Hall: Upper Saddle River, NJ, 1996.

5. Zeno W. Wicks, J.; Jones, F. N.; Pappas, S. P. Organic Coatings: Science and Technology; John Wiley & Sons, Inc.: New York, 1992 & 1994; Vol. 1 & 2

KEYWORDS: High Strength Steel, 300M Steel, Landing Gear, Corrosion Protective Coatings for Steel, Abrasion Resistant Coatings, Impact resistance, Gravelometer

AF03-110 TITLE: Low Cost Replacement for Current Screen Technology

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop screen wire suitable for use as a cavity cover to protect internal components.

Description: Protective screens are used on aircraft to protect window materials or infrared (IR) sensor systems from erosion damage caused by the flight environment. Technological advances are being pursued to identify candidate mesh material(s), stronger coatings, or cost-effective fabrication techniques for increasing the durability. As important as identifying these items is lowering the cost of the screens. A low cost replacement that at least meets the performance criteria of the current stainless steel wire mesh needs to be identified.

Phase I: Identify candidate screen material, more durable coatings or post treatment, or innovative processing techniques that can withstand the flight environment and performance requirements. Potential candidates would need to demonstrate proof of concept and provide a few samples for environmental testing. This testing will be conducted by the government.

Phase II: Demonstrate a new screen/aperture device and prove that the device meets present requirements including aerodynamic and transmission characteristics. An insertion loss measurement test will be conducted as a quick screening of potential candidates to identify minimum performance and acceptability. The desired outcome of this phase is a material, coating, posttreatment process or fabrication technique submitted for qualification testing as an alternate protective screen.

Dual Use Commercialization Potential: The developed technology would be a possible replacement for impact resistant or other electromagnetic protective screens for sensor systems. A commercial application would be impact protection for IR sensors on vehicles or commercial aircraft.

References: none

KEYWORDS: Rain Dispersive Mesh, Electromagnetic Interference Protective Screens, Wire Screens, Stainless Steel Screens, Opaque Grids

AF03-111 TITLE: Extended Life Corrosion Protection

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop an environmentally compliant (non-chrome, no volatile organic compound) corrosion protection coating system for aging military transport, bomber, trainer, and fighter aircraft that extends operational life by one depot cycle.

Description: Military aircraft utilize a complex coating system to impart camouflage, color, and corrosion protection. Currently, the corrosion protection components (surface treatment and primer) contain chromium compounds to inhibit the corrosion of the underlying aluminum structure. While these chromium compounds have excellent corrosion protective and inhibitive properties, they are hazardous carcinogens. In the near future, the AF may not be able to effectively manage the disposal and remediation of these materials.

A non-chrome, environmentally compliant corrosion protection system (surface treatment, primer, topcoat) with an operational life of approximately ten (10) years could save a typical transport aircraft fleet >$600M over the aircraft's life cycle.

This program would identify and develop candidate surface treatments, primers, and camouflage topcoats and evaluate operational performance (corrosion, weatherability, and durability). Recent advances in silicon based sol-gel and cerium based coatings show promise to achieve these goals.

Phase I: Identify and demonstrate the feasibility of coating system components (surface treatment, primer, topcoat) in simulated aircraft corrosion environments. Evaluate individual component and complete coating system corrosion, weatherability, and durability performance.

Phase II: Scale-up materials and processes to manufacturing scale. Produce coated subelements utilizing the coating system developed in phase one. Evaluate these comonents for weathering and corrosion performance. Produce a significant quantity (approx five gallons of each component) of the coating system for evaluation by the AF

Dual Use Commercialization Potential: Commercial aircraft would benefit from environmentally compliant corrosion protection coating sytsem with enhanced durability and corrosion resistance.

References:

1. Scott Hayes, James O. Stoffer, Thomas J. O'Keefe, T. Schuman, S. Patwardhan, E. Morris and Paul Yu, "Environmentally Compliant Aircraft Coatings," Polymer Materials Science and Engineering, 85, 140-141 (2001).

2. A.J. Vreugdenhil, V.N. Balbyshev, and M.S. Donley, "Nanostructured Silicon Sol-Gel Surface Pretreatments for Al 2024-T3 Protection," Journal of Coatings Technology, 73, 35 (2001).

KEYWORDS: corrosion protection, aluminum cerium, sol-gel

AF03-112 TITLE: Improved Life Prediction of Turbine Engine Components

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop improved tools for predicting fatigue lives under service conditions for gas turbine engine materials.

Description: Gas-turbine engine structural materials, such as titanium and nickel-base superalloys, are subjected to a complex spectrum consisting of numerous temperature and load excursions, depending upon the mission. Fatigue damage processes under engine operating conditions can be very complex, involving effects of loading frequency and stress ratio, fretting, creep, environment, and the interactions of these variables. [Ref 1,2] Presently, components are life managed based on TACs (total accumulated cycles), which represent a rough form of cycle counting. At the completion of a flight the number of TACs is added to the running total for a particular engine, and the components are life managed based on that number compared to the predicted (or design) life - also given in TACs. Due to the inexact application of "accumulated cycles" in accounting for the wide envelope of potential effects and interactions, numerous safety factors have evolved in fatigue predictions to minimize the effects on safety of flight. This has led to the possibility of an overly conservative life estimate for components. Physically based prediction tools are required to account for the actual mission conditions experienced by turbine engine rotating hardware. Ultimately, these tools need to take into account the effects of load-interactions, fretting, residual stresses, thermomechanical loading, dwell times, etc. on the fatigue threshold, growth of initial damage and microstructurally small cracks, transition from small to large cracks, and the growth of large cracks to failure. The tools also need to take into account the geometric and coupled component responses to loading, i.e. complex geometries, contact, bolting loads, etc.

Phase I: Develop physically based algorithm(s) either deterministic or probabilistic to predict or assess the useful fatigue life as a function of the key variable(s), i.e. temperature, load, residual stresses, frequency, hold time, environment, etc. Establish the feasibility with available data, or generate laboratory data to demonstrate the feasibility of the algorithm(s).

Phase II: Further development of analytical technique(s). Demonstration of the utility of the technique on laboratory and/or subelement tests under mission-like load and temperature spectra. Delivery of software code, developed under the SBIR contract, would be for evaluation purposes by AFRL and/or ASC in subcomponent, component, and/or engine validation testing.

Dual Use Commercialization Potential: The algorithm(s) and software codes developed to predict or assess the useful fatigue life of engine structural materials should be applicable to a wide variety of commercial applications including, but not limited to, commercial aircraft (engines and airframes), land based turbines, automotive and other transportation vehicles, and any industrial applications where fatigue and/or thermomechanical fatigue is the primary failure mechanism.

Related References:
1. Nicholas, T. and Larsen, J. M., “Life Prediction for Turbine Engine Components,” Fatigue: Environment and Temperature Effects, Plenium Press, New York, New York, Editors J. J. Burke and V. Weiss, pp.353-375, 1983.

2. Larsen, J. M. and Nicholas, T., “Cumulative-Damage Modeling of Fatigue Crack Growth in Turbine Engine Materials,”Engr. Frac. Mech., Vol. 22, No. 4, pp. 713-730, 1985.

3. Larsen, J. M., et. al., “An Assessment of the Role of Near-Threshold Crack Growth in High-Cycle Fatigue Life Prediction of Aerospace Titanium Alloys Under Turbine Engine Spectra,” Int. J. of Frac., Vol. 80, pp. 237-255, 1996.

4. Nicholas, T., "Critical Issues in High Cycle Fatigue," Int. J. Fatigue, 21, Supp. 1, 1999, pp. S221-S231.

KEYWORDS: life prediction, turbine engines, fatigue, crack growth, oad-interactions, residual stress, frequency, stress ratio

AF03-113 TITLE: Conductive Repair Coatings

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop a quick cure, conductive repair coating for electrostatic discharge applications

Description: Some specialized aircraft require a conductive surface coating to dissipate electrostatic charge and provide electromagnetic integrity over the outer surface of the aircraft. This conductive coating often is layered within other coatings. The repair of small (< 1 sq meter) damage areas and defects involves removing and repainting each individual layer, resulting in total repair times of > 24 hours. A quick cure, conductive repair coating is required with the following attributes:

a. Cure, or dry-to-fly within 4 hours after application,
b. Electrical surface resistance <20 ohms/square,
c. Capable of withstanding 6-12 months of service in a typical military aircraft environment,
d. Available in low gloss, gray to black color or appearance.

Phase I: The contractor will demonstrate the feasiblity of a quick cure, electrically conductive repair coating that meets the above requirements.
1) Develop processing, cure rate, and improved electrical conductivity mechanisms for previously developed repair coatings.
2) Demonstrate reduced cure time and improved electrical conductivity, moisture and ultraviolet radiation resistance of these coatings.

3) Produce four, one quart samples of the developed repair coating for AF evaluation.

Phase II: 1) Develop a processing/formulation technique to ease the transition of the coating formulation to scale-up.
2) Evaluate modifications to the basic repair coating chemistry and formulation to address conductive elastomer and filler putty requirements.
3) Produce significant quantities (10, 1-liter kits) to demonstrate the scale-up capability of the formulation.
4) Characterize the final coating formulation for cure, electrical conductivity, environmental resistance, and inspection techniques.

Dual Use Commercialization Potential: Conductive Coatings developed for the DoD could be applied to commercial aircraft electrostatic and electromagnetic shielding applications

Related References:
1. Donatas Satas and Arthur A. Tracton; "Coatings Technology Handbook"; 2nd ed.,New York : Marcel Dekker, c2001.

2. James H. Lindsay; "Coatings and Coating Processes for Metals"; Materials Park, OH : ASM International, c1998.

KEYWORDS: Electrical, Conductive, Coating, Electrostatic

AF03-114 TITLE: High Speed Forging of Titanium Components with Microstructural Control

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: The objective of this research topic is to explore and transition novel high speed forging technique to manufacture titanium components at faster rates without any defects.

Description: Titanium alloy Ti-6Al-4V is most widely used in aerospace industry for both engine and frame applications due to its attractive properties combined with good corrosion resistance. Component manufacturing in Ti-6Al-4V involves extensive mechanical working to obtain desired microstructure. Traditional approaches used for titanium alloy forging are not only slow but also likely to generate microstructural defects. Therefore, an effort has been made to explore the alternate processing routes. With the help of laboratory experiments, a novel high-speed process for titanium billet conversion has been discovered. The new process offers several advantages over the traditional process in terms of cost savings, mechanical properties, and microstructural control. However, for the new process to be used in the manufacture of aerospace components, it needs to be qualified through full-scale demonstrations and characterization.

Phase I: Evaluate the ultrasonic and eddy current response of the products manufactured using new high-speed process. Develop, test, and demonstrate the full-scale forging experiments and study the effect of process variables on microstructural evolution during scale-up. Evaluate the new process in terms of microstructure, mechanical properties, and performance through detailed analysis.

Phase II: Design and optimization of processing sequences incorporating the high speed process using advanced simulation and multi-objective optimization schemes. Generate material property data as per the military standards to standardize and qualify the new process for industrial use.

Dual Use Commercialization Potential: The new process will significantly reduce the manufacturing costs of titanium components used in commercial and military aircraft as well as any mechanical applications (such as transportation) that utilize titanium components.

Related References:

1. Microstructural evolution during hot working of Ti-6Al-4V at high strain rates, Conference Proceedings on Lightweight Alloys for Aerospace Applications VI, TMS, Warrendale, PA (2001) pp. 219-228

2. Microstructural conversion from lamellar to equiaxed in a titanium alloy: A novel high speed process, Air Force Invention # AFD 546, June 2001

KEYWORDS: Titanium, Forging, Process design, Optimization

AF03-115 TITLE: Thermal Barrier Coatings for Titanium and High Temperature Polymeric Composite Components

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Thermally protective coatings for titanium (including titanium alloy) and polymer composite components would permit substitution of such components for heavier, high temperature alloy components. In addition, the reliability and service life of the titanium components and polymer matrix components would be enhanced by thermally protective coatings.

Description: Novel materials and methods are sought to produce thermally protective coatings on representative titanium and polymeric composite compositions. Coating materials and methods proposed should allow for the high reactivity of titanium and titanium alloys and thus the possibility of embrittlement of the substrate materials by either or both the coating material and the coating application process. Methods to avoid both problems, possible reaction with and embrittlement of the substrate material, and to maximize coating or interlayer integrity, should be clearly outlined. Coatings must provide protection of the substrate material to transient temperatures of at least 900ºF (exposure temperature at coating external surface). In addition to preserving substrate material mechanical properties, coating materials and methods should be applicable to a variety of complex shapes.

Phase I: The research should demonstrate, at the coupon level, the coating materials and methods and the retention of mechanical properties of the titanium or polymer composite substrate both as-coated and following transient thermal exposure.

Phase II: The developed coating materials and application processes should be optimized and demonstrated on actual components which can be subjected to independent test and evaluation.

Dual Use Commercialization Potential: Successful completion of the proposed research would permit substitution of lightweight protected titanium components or polymer composites for heavier, high temperature alloy components in non-rotating components for military and civilian turbojet engines and certain exhaust-washed structures of advanced aircraft.

Related References: Anthony G. Evans, Conference Summary 98-2, Workshop Report on Thermal Barrier Coatings, Conference Summaries, Office of Naval Research International Field Office Newsletters, http://www.ehis.navy.mil/onrnews.htm.

KEYWORDS: Thermal barriers, coatings, titanium, titanium alloys, polymer composites.

AF03-116 TITLE: Repair of HighTemperature RAM Coatings

TECHNOLOGY AREAS:

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Affordable, low cost repair methods are sought for high temperature radar absorbing material (RAM) coatings. New repair techniques that can be performed in the field and "on-wing" are required.

Description: Application techniques of interest would include, but are not limited to, slurry spraying or cementatation to be followed by an in-place localized curing operation. Innovative, low temperature curing techniques are particularly of interest since these are required to produce a robust and adherent on-wing repair without exposing the underlying structural to unacceptably high temperatures. A thorough understanding of a variety of suitable filler material and ceramic or glass/ceramic matrix is required in order to produce an acceptable repair material that matches the properties of the current coating materials. A thorough understanding of inter-constituent chemical compatibility issues is also required in order to maintain the usefulness of the filler materials. If surrogate materials are to be used in the proposed work, a complete justification for the use of such materials must be provided. Proposers should provide evidence that any required personnel and facilities security clearances are currently in place.

Phase I: The research should demonstrate, at the coupon level, the various repair materials and methods. A preliminary mechanical and electrical property data base should be generated to validate the repair method. This should include data on both as-produced repair materials and repair materials which have extended thermal exposure.

Phase II: The developed repair materials and application processes should be optimized and a more complete engineering property database generated. The repair materials and processes should be demonstrated on actual components, which can be subsequently subjected to independent test and evaluation.

Dual Use Commercialization Potential: Although the use of these materials is predominately military in nature. Possible dual use applications include the reduction of side lobes for high power radars.

Related References: "Maintainability Session," Have Forum 1999 Low Observable Symposium, San Antonio, Texas, Volume 1, AFRL-SN-WP-TR-1999-1129, Unclassified Proceedings, May 11 – 13, 1999.

KEYWORDS: Repair, coatings, radar absorbing materials, RAM.

AF03-117 TITLE: Modeling of Laser Additive Manufacturing Processes

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: To develop process-modeling capabilities for laser additive manufacturing of metallic aerospace components.

Description: Laser additive manufacturing (LAM) is a fabrication method which can be used to manufacture metallic components directly from computer-generated 3D drawings. In this process, metallic powder is directed toward a substrate and melted by a sharply-focused laser beam. Parts are built up layer-by-layer by moving the laser and powder source across the surface of the underlying material. In this manner, free-standing shapes are generated without molds or dies. This emerging manufacturing process is currently of high interest to the US Air Force for use in fabricating metallic aerospace components based on its potential to reduce delivery times and buy-to-fly ratios. The Air Force is soliciting proposals to develop new process-modeling capabilities for LAM to speed its development and maturation. The models shall be utilized to gain an understanding of the effects of process variables on the evolution of features such as shape, defects, residual stresses, and microstructure for use in process development and optimization.

Phase I: This program shall focus on demonstrating the feasibility of the selected approach for modeling the LAM operation. Feasibility shall be adequately demonstrated by validating the Phase I model against measurements obtained during steady-state deposition of a simple geometry. Proposals should demonstrate reasonable evidence that this proof of principle can be obtained within Phase I. Interaction with the aerospace metals-processing industry is highly desirable.

Phase II: This program will be structured to develop and refine the model to the point where performance can be physically demonstrated for a complex geometry. The model shall provide quantitative information on the effects of changes in process parameters on deposit characteristics to permit an evaluation of the ultimate application potential to meet Air Force needs. At the conclusion of Phase II, the contractor shall deliver a written report which illustrates the accuracy with which the model is able to predict the features of complex deposits. Additionally, the model and appropriate documentation shall be delivered to the Air Force for government use and evaluation.

Dual Use Commercialization Potential: The developed approaches will have broad commercial applicability due to the large number of alloys and configurations which can be fabricated via LAM and the large number of commercial air, space, and engine systems that have affordability and schedule requirements similar to those faced by DoD.

Related References:
1. B. Cleveland, in: Advanced Materials & Processes, 159 (5) (2001), p. 32.

2. D. Keicher, in: Advanced Materials & Processes, 159 (5) (2001), p. 35.

KEYWORDS: Process Modeling, Laser Additive Manufacturing, Affordability, Metals, Alloys, Heat Transfer, Residual Stress, Microstructure

AF03-118 TITLE: <u>Enhanced Strength Aerospace Carbon Foam Heat Exchanger</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: The Air Force is seeking new and highly innovative concepts for using affordable carbon foam for aircraft thermal management heat exchanger applications.

Description: Carbon foam heat exchangers are predicted to weigh 50% less and be twice as efficient as existing aircraft heat exchangers and, therefore, are being considered for use on helicopters and small cargo aircraft. Due to structural limitations, however, their use on high performance aircraft is limited. This effort requires novel, structurally- tailored foam processes and associated architectures be examined to facilitating their use on aircraft with high engine bleed-air pressures. This effort should also focus on satisfying the structural and thermal requirements for heat exchangers that are located in fighter aircraft engine fan-duct bays, where vibration and acoustic loads are substantial.

Many enhanced properties of open- or closed-cell foams can be tailored by varying porosity/density/cell size. Graphitic high-conductance tailoring, foam structural ligament enhancement, coatings, and other techniques can be used to expand heat exchanger operation to be compatible with all high performance engines, both military and commercial. Oxidation protection for this effort will be limited to a median-temperature protection below 800 oF (427 oC).

Phase I: The Phase I program will demonstrate the feasibility of the proposed enhanced-strength carbon foam core concept sufficiently to justify further development and/or scale-up in a Phase II effort. Proof-of-concept core sub-components will be fabricated and tested and should possess structural properties sufficient to contain the high engine bleed-air pressures required for heat exchanger applications.
Phase II: The concept(s) demonstrated in Phase II will be full scale as a carbon foam heat exchanger, developed in detail, thermal and pressure-drop performance tested and delivered. The payoff and benefits of the technology will be demonstrated by fabrication and testing of a component.

Dual Use Commercialization Potential: The use of an efficient thermal management material can enhance thermal performance and significantly reduce heat exchanger weight. Thermal management is an issue for commercial as well as DoD platforms. Commercial aircraft Environmental Control System (ECS) heat exchangers, along with other aerospace internal structural and engine cooling applications, have similar requirements to reject heat. Other potential applications are marine salt-water heat exchangers and cryogenic heat exchangers for spacecraft.

Related References:
1. Development of a Portable Shear Test Fixture for Low Modulus Porous (Foam) Materials, Ajit K Roy, AFRL/MLBC and John D. Camping, UDRI, 8 Aug 2000, PR ASC -00-1650

2. Development of a Compression Test Configuration for Carbon (Brittle) Foam, Ajit Roy, 13th International Conference on Composite Materials, Beijing China, June 25-29, 2001, PR ASC 01-0339

3. Carbon Explosion, Racecar Engineering, March 2001, V11, No.3

KEYWORDS: Heat Exchanger, Graphitic Foam, Thermal Management, Carbon Foam, Structural Foam, Material Development

AF03-119 TITLE: Gas Turbine Engine Oil Additives For Advanced Bearings - Advanced Steels

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: To generate innovative technology for novel, effective gas turbine engine oil lubricity antiwear additives for new advanced steels.

Description: Creative and innovative gas turbine engine oil additive technology is needed for advanced engine bearings. In order to meet the requirements for improved performance and longer life, the engine companies have investigated the possibility of using advanced, high-temperature, high-speed, corrosion-resistant and fatigue resistant steels in engine bearings. The new advanced bearing steels include Pyrowear 675, Cronidur 30, Cru-20 (Rex 20) and CCS 42L. These new bearing steels are obvious candidates for incorporation into new gas turbine engines. In performance tests conducted to date, however, bearings based on these technologies have experienced significantly shorter life than anticipated.

Thus far, the current gas turbine engine oils (GTOs), MIL-PRF-7808 and MIL-PRF-23699, have been used in the performance tests of bearings constructed of these advanced materials. The current GTOs have been formulated specifically to provide excellent elastohydrodynamic and boundary lubricating performance to the existing steel based bearings e.g., 52100 and M-50. They contain aryl phosphate additives, which have been proven to work very well with the current low chrome containing bearings. The aryl phosphate additives form a lubricious coating when activated by a fresh iron surface created by asperity contacts within the bearing while operating.

The chemistry of the new, advanced bearing steels does not interact in the same way with the aryl phosphate additives to form the lubricious, life extending films. The purpose of this topic is to generate creative, innovative technology for novel, effective lubricity additives to enhance the performance of bearings using the new advanced steels.

These additives must be effective as lubricity additives while not increasing the deposit forming tendencies of the lubricant formulations when they experience the high temperatures in gas turbine engines. They also must remain in solution at effective concentrations over the desired operational temperature range of the GTO and, in general, allow the formulations to meet existing military GTO specifications.

Phase I: Phase I shall include the synthesis and initial demonstration of novel additive technology for use in high temperature GTOs with advanced steel bearings. Candidate additives from industry may also be explored. The formulations shall demonstrate good performance in boundary lubrication compared to a baseline, currently used MIL-PRF-7808, Grade 4, GTO with 52100 steel. Potential offerors may desire to include engine companies, the customer for this technology, in their program plans.

Phase II: Phase II shall include scale-up of additive technology and more extensive evaluation of candidates from Phase I or newly discovered additives. Performance under boundary lubrication and rolling/sliding lubrication shall be demonstrated compared to currently-used MIL-PRF-7808, Grade 4, and 52100 steels. Longer-term tests with bearing steels as described in the Description shall be conducted. Data from bearing tests shall include a minimum of 6 high speed and high load bearing tests including a baseline under realistic advanced engine conditions. A minimum of 5 samples of a minimum of 200 gm each of the most promising additives shall be provided at the end of the effort. Potential offerors may desire to include engine companies, the customer for this technology, in their program plans, with engine testing as a goal.

Dual Use Commercialization Potential: Dual Use Applications: Dual use applications include municipality power generation turbines, which have similar issues to aircraft gas turbine engines. Another commercial application is for commercial aircraft because commercial aircraft engine advancements usually follow military advancements by about 5 years. Medical equipment may also benefit from corrosion-resistant bearings and effective antiwear additives because of high temperature, harsh gasses required for operations and heavy usage of the equipment.

Related References:
1. Lee, E. U. and Waldman, J., "Corrosion of Aircraft Landing Steels," Nav. Eng. J. 1994, 106, pp. 77-83.

2. Tucker, J. G., "Elastomeric Polyurethanes Used as Coatings in the Arduous Conditions of Severe Corrosion and Abrasion," Anti-Corrosion Methods and Materials, 1986, 33, 10/13.

3. Osborne, J. H., Blohowiak, K. Y., Taylor, S. R., Hunter, C., Bierwagen, G. P., Carlson, B., Bernard, D., and Donley, M. S. "Testing and Evaluation of Non-Chromated Coating Systems for Aerospace Applications," Progress in Organic Coatings 2001, 41, pp. 217-225

4. Jones, D. A. Principles and Prevention of Corrosion; 2 ed.; Prentice Hall: Upper Saddle River, NJ, 1996.

5. Zeno W. Wicks, J., Jones, F. N., and Pappas, S. P. Organic Coatings: Science and Technology, John Wiley & Sons, Inc.: New York, 1992 and 1994; Vols. 1 and 2.

KEYWORDS: gas turbine engine, oil additive, high-temperature, corrosion-resistant steel, fatigue-resistant steel, high-speed bearing, lubrication, lubricant

AF03-120 TITLE: <u>Determination of Micorcracking Damage in Composites</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Space (SP)

Objective: Develop a nondestructive approach to quantify the overall area and maximum depth of micro-cracking damage in the composite skin of a honeycomb sandwich structure.

Description: Damage in the composite skin is due to excessive thermal and /or moisture exposure and is in the form of micro-cracking at the fiber resin interface. Micro-cracking may be in any orientation and at one or more plies within the same region.

The structure of concern consists of a woven glass/polyimide honeycomb core with a skin of 5 plies of woven S-2 glass bonded to each side. The region of interest containing the micro-cracking damage is limited to the skin plies. The skin plies are 9-12 mils thick combining for a total skin thickness of 0.045 - 0.060." The ply orientation of the composite skin is 0/+45/0/+45/0. The height of the core tapers from approximately 6.00 inches to nearly zero. AFRL/MLSA will provide representative specimens with and without damage.

Phase I: Demonstrate the feasibility of a nondestructive inspection technique capable of detecting and quantifying the overall size and depth of micro-cracking within composite skin plies. The technique should be able to detect micro-cracking in successive plies to a depth of 0.060 inches.

Phase II: Optimize the inspection technique and develop a prototype inspection system. Demonstrate the prototype system capabilities on representative aircraft components.

Dual Use Commercialization Potential: This technology would be directly applicable to any aircraft or space system using thin composite skins.

Related References: Masters, J.E. and Reifsnider, K.L., "An Investigation of Cumulative Damage Development in Quasi-Isotropic Graphite-Epoxy Laminates," Damage in Composite Materials, ASTM STP 775, K.L. Reifsnider, Ed., American Society for Testing and Materials, 1982, pp. 40-62.

KEYWORDS: Micro-cracking, composites, heat damage, moisture damage, nondestructive inspection.

AF03-121 TITLE: <u>Filter for Airborne Pathogens and Toxic Liquids</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

Objective: Develop a device or sequence of low-pressure-drop devices to remove airborne pathogenic organisms and liquid chemical pollutants at near-ambient temperatures.

Description: During attacks by chemical and biological weapons, personnel in temporary or permanent shelter[s] are dependent on a constant supply of clean air; therefore, ventilation systems are both a direct and an incidental target for terrorists and saboteurs. Current-generation HEPA filters provide reasonable protection for a practical amount of time, but they are expensive to acquire, require the use of prefilters to limit their rate of loading, and dissipate a large amount of power from the ventilation air stream. An alternative approach might use one or a sequence of less-efficient devices to achieve a satisfactory level of protection, and could be operated on a constant basis if they were capable of regeneration in place.

Any proposed technology should not emit a detectable signature or measurable amounts of hazardous or air toxic materials. No other constraint is placed on the technology to be proposed, other than the usual conventions of safety, practicality, and affordability. Preference will be shown to approaches that do not build directly on technology already demonstrated to be effective against bacteria in filter applications, that address both chemical and biological contaminants, and that can be regenerated or reactivated in place. However, more-selective items may also be considered as possible components of a multilayer or multistep system.

Phase I: During phase I, the contractor will demonstrate feasibility of a bench-scale example of the proposed technology that will remove 99.9% of an aerosolized phosphate ester or of a viable microorganism delivered in a flowing air stream.

Phase II: During phase II, the contractor will develop an engineering prototype and use it to demonstrate 99.9% removal of applicable contaminants from a 10,000-cfm stream of air stream to an accumulated loading. This demonstration will be repeated at no fewer than three different conditions of temperature and relative humidity [covering spreads of 100 C and 90% RH], and no fewer than three distinct interferents will be delivered into the air stream at widely separated intervals during the course of the demonstration.

Dual Use Commercialization Potential: Exclusive of homeland defense, the principal commercial opportunity is as an infection control/allergy suppression accessory in isolation masks and in private residence, aircraft, and business ventilation systems, including medical and microbiological facilities. There are also likely to be analogous military applications.

Related References:

1. http://www.anachemia.com/defequip/product.html Constituents in M-8 papers react with several categories of chemical agents.

2. http://www.nbcindustrygroup.com/handbook/pdf/RESEARCH&
DEVELOPMENT.pdf Halogens in a functionalized polystyrene resin act as a filter that kills pathogens in water as it passes through

3. http://www.fossmfg.com/fosshield.htm Silver distributed in a filter kills pathogens in air as it passes through.

KEYWORDS: aerosol, chemical agent, biological agent, TIMs, infection, ventilation, filter, HEPA

AF03-122 TITLE: Novel Flame and Impact Resistant Foam Core

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

Objective: Develop affordable novel lightweight, high flame resistant "composite" foamed core compositions with improved impact resistance

Description: True fiber reinforced composite structures are acknowledged to surpass many metallic structural monolithic materials in applications which require weight savings, fuel efficiency, and corrosion resistance. Recent attractive applications of monolithic structural composites consist of replacements for the crumbling infrastructure of buildings, bridge decks and piers, and high performance, high speed racing sport and civilian transport vehicle components. Previous AFRL technical efforts have demonstrated the feasibility of using foamed organic polymeric matrices to improve toughness and impact resistance of neat monolithic and "composite" core structures. The purpose of this SBIR topic is to develop affordable foamed core "composite" formulations and walled structures that are very light weight, flame resistant and impact resistant. The combined foamed core and additional design components will possess well-characterized load bearing capability with enhancement of the "composite" flame retardancy and impact resistance. This effort should focus on the processing methodology and characterization of the foamed "composite" sandwich compositions as physical or chemical blends, fabrication processes of gas-assist structural foams and design concepts for reinforced systems, and finally characterization of the novel "composite" sandwich structure. Material selection should consider excellent flame resistance, impact resistance and high modulus for both the matrix and especially any reinforcement. Consideration must also be given to the ability to scale the proposed processing and fabrication methods by Phase II completion to large structures in excess of 6 sq. ft.

Phase I: The contractor shall develop processing schemes for the foamed "composite" core materials which result in improved flame and impact resistance. Reinforcement concepts may include, but not be restricted to, fiber tows, chopped fiber, and continuous fiber weaves and co-weaves. Polymeric matrices may include, but not be restricted to, flame resistant liquid crystalline polymers, cyanate esters, vinyl esters, phenolics and phenolic blends, high performance polymer resins and hybrid nanostructures. Characterization of the physical, thermal and thermal analytical properties of any novel matrix proposed shall be conducted in order to develop eventual full thermo-mechanical characterization of the "composite." The matrix and "composite" formulations shall be evaluated for flame resistant performance which include: determination of the peak, average and total heat release rates, heat of combustion and ignition time, combustion efficiency, mass loss rates, smoke density and char yields at a radiant heat flux of 35 kW/m (squared) using calorimetric methods. Thermomechanical property evaluation shall be conducted at room temperature and at elevated temperatures near radiant heat flux values of 75 kW/m (squared). Finally, characterization of the impact properties of the materials shall be accomplished using gas gun ballistic test protocol at various threat levels. Products of this Phase I effort shall be data and a proof of concept flat sandwich structure deliverable of dimensions nominally of 0.60 inches thick face sheets surrounding 1.00-inch thick core x 1-2 square feet.

Phase II: Based on the results of Phase I research, the contractor will further develop the foamed "composite" core structure processing methods to be implemented for the production of a realistic sized test article. The flame resistance testing shall continue in Phase II to include temperature exposures up to 100 kW/m (squared). Ballistic and impact testing will continue to higher threat level quantification. The processing should be altered to mimic realistic production level fabrication conditions of large structural components and maintain thermo-mechanical, flame, and impact performance in scale. Products of this Phase II effort shall be data and deliverables with dimensions of 0.060 inches thick face sheets surrounding 1.00-inch thick core and of reasonable size to enable both indoor and outdoor live fire testing.

Dual Use Commercialization Potential: Foamed structures of mixed compositions of matter have significant military and commercial applications, of utmost priority as light weight but sturdy, flame and impact resistant military aircraft structures with replacement of honeycomb core and light weight, portable personnel protective barriers. Commercial opportunities envisioned are high volume, acoustic deadening, flame-resistant firewalls for racing circuit and passenger cars, and air personnel vehicles.

Related References:
1. R. Stadlemann, "Facts to Remember When Using Core Materials," Reinforced Plastics 44 (5), 44-46 (May 2000).

2. G. Marsh, "Meat in the Sandwich," Reinforced Plastics 43 (5), 28-35 (May 1999).

3. D. R. Ambur, "Design and Evaluation of a Foam-Filled Hat-Stiffened Panel Concept for Aircraft Primary Structural Applications," NASA-TM-109175 (NTIS N95-26251/5 (Jan 1995)).

4. J. S. Tomblin et al., "Impact Damage Characterization and Damage Tolerance of Composite Sandwich Airframe Structures," DOT/FAA/AR-00/44 (DTIC ADA388041 (Jan 2001).

5. D. Zenkert, "Effect of Manufacture-Induced Flaws on the Strength of Foam Core Sandwich Beams," in Damage Detection in Composite Materials; Philadelphia: Am. Society for Testing and Materials, Vol. 1128, 137-151 (1992).

KEYWORDS: Polymers, polymer foams, flame resistance, ballistic resistance, fracture toughness, modulus, penetration resistance, areal density

AF03-123 TITLE: <u>Hidden Threat Detection Techniques</u>

TECHNOLOGY AREAS: Materials/Processes

Objective: To develop and test hidden threat detection techniques tailored for Air Force applications.

Description: This topic seeks to capitalize on emerging non-contact nondestructive evaluation (NDE) detection techniques as well as revolutionary concepts for sensors and detectors and tailor them to specific applications for personnel protection. Specific applications may include but not be limited to: tailored nondestructive detection techniques for quickly detecting specific shapes (weapons) and contraband materials (C4, TNT, gunpowder, etc.); implementation of Micro-Electro-Mechanical Systems (MEMS) technologies for chemical/biochemical reactions to enable detection of animal life in a given area (e.g., for the detection of hidden humans); microwave frequency and electro-magnetic methods for the detection of hidden materials on personnel and in vehicles (non-metallic knives, firearms, other contraband); and the integration with Biological Detection Systems (Biomaterials) for the Identification of Friend-or-Foe (IFF). In each case, computational methods (advanced signal processing, pattern recognition, data fusion, etc.) could play a vital role in assessing hidden threat, including potential intent. This topic will develop or transition technologies such as: biotechnology, MEMS technologies, nanostructured materials, etc. with advanced NDE hidden threat detection techniques to meet Air Force security application requirements.

Phase I: Will consist of a preliminary feasibility demonstration of the proposed concept using real or simulated materials or conditions representative of the targeted threat. This phase should include an initial assessment of the concept technology's potential capabilities. Additionally, a preliminary concept of operations should be developed for the user community.

Phase II: Will include a comprehensive demonstration of the developed concept from Phase I. It will also include design and construction of prototype instrumentation and software to implement the concept in practical environments. An element of the development should include a preliminary field evaluation by the user community.

Dual Use Commercialization Potential: The technology developed as part of this topic will have significant applications in both the civilian and military environments. Potential applications include, but are not limited to: walkthrough portals for personnel screening, detection and mapping of underground facilities, through-wall imaging, standoff explosive detection, and cargo screening.

Related References:

1. Homeland Defense Website (http://www.whitehouse.gov/homeland)

2. Defend America Website (http://www.defendamerica.mil)

3. Noble Eagle Website (http://www.af.mil/news/noble)

KEYWORDS: nondestructive evaluation, micro-electro-mechanical systems, nanotechnology, biocatalysis, force protection, homeland defense

AF03-124 TITLE: Window Materials for Airborne Directed Energy Applications

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

Objective: Develop an approach for innovative window materials technology to enable the application of high-energy laser (HEL) and high power microwave (HPM) DE devices onboard future Air Force airborne systems.

Description: Future AF systems will employ directed energy in the form of high-energy lasers or high-power microwaves to produce weapons effects. Materials and processing technology for improved window materials to is required to enable incorporation of these devices on board air vehicles. DE windows (transparencies/ radomes) require high transmission of energy from DE devices while providing improved properties required for long life, affordable airborne application. These improvements may result from improvements in the structural window material, use of property improving coatings or additives, use of conformal designs, or other innovative approaches. Properties must allow windows to be robust, lightweight, and aerodynamically compatible. The selected materials systems must be amenable to large-scale fabrication methods or suitable segmentation to meet the application size and performance requirements. Improved transmittance, strength, hardness, toughness, and thermal shock resistance, as well as decreased scatter, absorptance, and cost are developmental areas with potential for significant improvements over current state of the art materials. As an example, properties may be improved through the use of innovative approaches such as microcrystalline, composite, or nano composite structures, high optical quality anti-reflective (AR) coatings with a minimum hardness equivalent to sapphire, or through other innovative approaches.

Phase I: Develop a viable materiasl and process technology approach for implementation of window materials in airborne DE applications. Demonstrate performance improvements on coupon sized test samples large enough to allow measurement of application relevant properties and demonstrate feasibility.

Phase II: Using the concepts of Phase I, the offeror shall develop processing capabilities for demonstrating the technology on prototype windows large enough to show applicability and scalability. The demonstration article shall be tested to show that the improvements in performance measured during Phase I are repeatable and that the article performs under anticipated use conditions. The offeror shall demonstrate the cost effectiveness of the improvement with a cost analysis of the window fabrication and show any cost avoidance resulting from the performance improvements.

Dual Use Commercialization Potential: If successful, the technology could be transitioned immediately to one or more advanced DE weapon insertions of direct interest to the Air Force. Commercial benefits include improved competitive opportunities for providers of aerospace windows. These window materials would find commercial use in visual, IR, and/or RF transparencies for aircraft and launch vehicles, chemical processing windows, and high-energy lighting element holders.

Related References:

1. Handbook of Laser Science and Technology, M.J. Weber, ed., CRC Press, 1986
2. AGARD Advisory Report No. 75 on "Avionic Radome Materials, ed. R.H.Cary, 1974
3. Microwave Materials & Fabrication Techniques, 2nd edition, Thomas Laverghetta, Artech House, Inc. , 1991

KEYWORDS: Laser Window, IR Transparency, Optical Coatings, RF Transparency, High Power Microwave, Radome, Directed Energy

AF03-125 TITLE: Narrow Band, High Reflectivity Optical Elements in the Infrared

TECHNOLOGY AREAS: Materials/Processes

Objective: Develop high-reflectivity narrow-band infrared mirrors

Description: For infrared optical applications in military systems it is often necessary to use filters which reflect light of a given narrow wavelength band while transmitting all other wavelengths. High performance gratings are traditionally used to achieve narrow band reflection, but it is difficult to achieve reflectivity of 90% or higher with a grating. The reflectors obtained by depositing multilayer or continuously varying coatings do provide high (~99%) reflectivity but they typically have a broad bandwidth or are physically too thick. Selected substrate and coating materials must transmit (i.e. have low absorption) in both the midwave (3 to 5 microns) and longwave (8 to 12 microns) infrared. Improvements may result from coating design methodology, deposition rates, residual stresses, deposition monitor and control, or other innovative approaches. In addition, we seek novel optical coating designs and innovative deposition processes that yield highly transmissive (~ 95% or greater) infrared filters having a longwave reflection band with 99% or higher reflectivity at the peak wavelength and a full width half maximum bandwidth which is narrower than that of a conventional quarter-wave stack.

Phase I: In Phase 1, the feasibility of the proposed approach shall be clearly demonstrated through optical coating designs with accompanying spectral performance models and through preliminary depositions on coupon sized infrared substrates of at least 1-inch diameter. A specific wavelength in the longwave infrared will be selected and the optimization of transmissivity, reflectivity, and bandwidth shall be demonstrated by a comparison of measured to modeled spectral properties, while also addressing cost and environmental durability in detail. The offeror shall also produce processing scale-up plans to be utilized in Phase II

Phase II: The phase II of the project will be based on the success of the Phase 1 work. In Phase II, the offeror shall fabricate highly spectral uniform coatings on 4-inch diameter mirrors with high reflectivity centered at several discrete infrared wavelengths. Phase II will also include performance testing of the optics using high resolution spectrometers as well as some environmental durability tests.

Dual Use Commercialization Potential: With reflectivities higher than that can be obtained with gratings, narrow-band filters will have a very widespread use in a variety of military, commercial and industrial applications in the infrared. Some of these applications include chemical agent detection, atmospheric environment sensing, material processing and laser surgery.

Related References:
1. W. E. Johnson and R. L. Crane, "Introduction to rugate filter technology", J. A. Dobrowolski and P. G. Verly, Editors, Proceedings of Inhomogeneous and Quasi-Inhomogeneous Optical Coatings (Quebec, Canada, 19-20 August 1993), SPIE volume 2046

2. LWIR spectral properties of CVD diamond at cryogenic temperatures, Diamond and Related Materials, January 1997, vol. 6, no. 1, pp. 169-171(3) , Clement R.E.

KEYWORDS: materials, coatings, optical materials, optical filters, optical coatings, infrared optical materials, infrared filters

AF03-126 TITLE: Durable Hybrid Thermal Protection System

TECHNOLOGY AREAS: Materials/Processes

Objective: Develop a durable thermal protection system for spacecraft and reentry vehicles that exploits the benefits of metals, ceramic, carbon-carbon and other enabling technologies.

Description: Thermal protection systems (TPS) on leading edges, control surfaces, and over large areas of the skin represent a crucial need for next generation reentry and military space vehicles. The reusable TPS currently employed by NASA on the Space Shuttle requires rehabilitation after each mission and offers no multi-functionality. Current thermal protection systems are merely thick ceramic tiles or carbon-carbon that serve as insulators while offering no structural benefits, adding deadweight that must be considered in the payload and flight profiles. The effort will attemp to overcome the shortcomings of state-of-the-art TPS by considering novel designs that draw from the strengths of organic matrix composites, carbon-carbon composites, ceramic matrix composites, and metal matrix composites. The hybrid design will be multi-functional, insulating the air-vehicle during reentry while contributing to the structural performance of the airframe. The technology to create a hybrid TPS is available, but a program is needed to bring the different technologies together into one integrated design. A government panel made up of representatives from the Air Force and NASA will assess the technical results and the military/ commercial viability of the hybrid TPS throughout the effort.

Phase I: The objective of Phase I will be a feasibility demonstration of a TPS design that does not rely solely on one material or technology. The concept is expected to include a number of advanced technologies such as ceramic matrix composites, carbon-carbon composites, aerogels, carbon foams, and high temperature metals. The goal is to start with the design requirements and iterate on the material selection to achieve a concept that uses the right materials for the right applications. Phase I will include a materials review, design requirements definition, conceptual design, preliminary structural and thermal assessment. It is highly desirable that the contractor think "out-of-the-box" prior to conceptual design to avoid returning to state-of-the-art monolithic thermal protection systems.

Phase II: Phase II will take the conceptual design from Phase I and assess the thermal and structural compatibility of the materials proposed. Joining techniques to integrate the different materials will be developed. Detailed thermo-mechanical analyses will be performed to determine the internal stress-state of the hybrid design as well as to determine the external boundary conditions. A sub-component utilizing the TPS design will be fabricated and, depending on the remaining funds, tested in a high heat flux environment representative of the design requirements given in Phase I. A final report summarizing the findings and a commercialization report will be written.

Dual Use Commercialization Potential: Military and civil reusable launch vehicles, and reentry systems for space.

Related References:

1. Strauss, B., Hulewicz, J., "X-33 Advanced Metallic Thermal Protection System," Advanced Materials and Processes, Vol 151, No 5, May 01, 1997.

2. Fricke, J., Emmerling, A., "Aerogels," Advanced Materials, Vol 3, No 10, October 01, 1991.

3. Schmidt, D., Davidson, K, and Theibert, L.S., "Unique Applications of Carbon-Carbon Composite Materials," three part series, SAMPE Journal, Vol 35, Part 1 - No. 3 May/June, Part 2 - No. 4 July/August, Part 3 - No. 5 Sept/Oct, 1999.

KEYWORDS: Thermal protections system, leading edges, advanced materials, carbon-carbon composites, ceramics, high temperature metals, carbon foams, aerogels, hypersonic, reuseable launch vehicle

AF03-129 TITLE: Inductively Coupled Initiation Systems

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: Air Armament Center (AAC)

Objective: Develop inductive coupling to non-destructively evaluate and initiate the explosive train in a fuze.

Description: Currently, to initiate fuzes in munitions, a physical connection of either high or low voltage is employed to ignite initiators and/or detonators to begin the fuze initiation process. There are many advantages to this set-up, mainly simplicity, however, it does not allow evaluation of the fuze without destruction. One possible solution for evaluation of fuzes without destruction is incorporating inductively coupled energy transfer to initiate the fuze. This will allow for a low voltage signal to be increased to the desired voltage without direct physical contacts in the fuze - thus eliminating losses due to conductivity inefficiencies. In addition, with inductive coupling, fuzes could be lot tested without destroying the "one-shot" items and verify that the fuze is operating properly before deployment. This would increase reliability and testability in fielded fuzes.

Phase I: In Phase I, the investigation of the proposed concept should result in a preliminary design to be included in the final report. An analysis of alternatives between different concepts should also be conducted to ensure the most efficient transition of energy in the fuze as well as to ensure testability of the fuze in the field.

Phase II: The phase II should include the design, fabrication and demonstration of the chosen concept(s). The demonstration should include voltage step-up data as well as data that indicate the concept(s) are viable for testing in the field.

Dual Use Commercialization Potential: The dual use application for this technology has many medical uses for evaluation and testing of medical devices non-intrusively to ensure proper operation. In addition, inductive coupled devices can be used in any application where physical contact for energy transfer is not desired.

Related References:

1. www.silciondesigns.com

2. DoD Dictionary of Military Terms (http://www.dtic.mil/doctrine/jel/doddict)

3. The Ordnance Shop (http://www.ordnance.org/gpb.htm)

4. DTIC REFERENCE: AD Number: ADA274993
Subject Categories: Electrical And Electronic Equipment Energy Storage Electricity And Magnetism, Corporate Author: General Atomics San Diego CA , Title: 100kA, 5000V Solid-State Opening Switch for Inductive Energy Storage.

5.Personal Authors: Heyse, Mark W.; Kolawole, Joshua; Taconi, Nolan E., Jr.; Bowles, Ed E. , Report Date: DEC 93, Contract Number: F08635-90-C-0241

KEYWORDS: inductive coupling, fuzes, initiation, voltage tranformation, explosive inititation, non-destructive initiation

AF03-130 TITLE: Optical Initiation of Explosives

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: Air Armament Center (AAC)

Objective: Develop an innovative technology that can reliably initiate explosives with a very low energy optical signal.

Description: Very low energy optical initiation of fuzing systems would eliminate the need for high energy density storage in a fuze, thus decreasing the fuze size and complexity. To accomplish this task, an innovative method for very low energy optical initiation of the explosive is needed. This innovative solution must be approximately an order of magnitude less energetic than current optical initiation systems and compatible with existing weapon systems and applicable safety standards.

Phase I: The phase I effort should investigate feasibility concepts and methods for optical initiation and the analysis of alternatives should be presented in the final report. Emphasis should be placed on very low energy initiation of explosives.

Phase II: The phase II effort should include the demonstration of the innovative concept(s) developed in Phase I. The innovative research demonstration should focus on the very low energy aspect of the initiation process.

Dual Use Commercialization Potential: Dual use applications for this technology include pyrotechnics for the entertainment industry as well as micro-detonators for satellite micromanipulation.

Related References:

1. www.sandia.gov.
2. DoD Dictionary of Military Terms (http://www.dtic.mil/doctrine/jel/doddict)
3. The Ordnance Shop (http://www.ordnance.org/gpb.htm)
4. DTIC REFERENCE AD Number: ADA360478, ProxyURL/Handle: http://handle.dtic.mil/100.2/ADA360478
Subject Categories: Lasers And Masers Optical Detection And Detectors,
Corporate Author: Johns Hopkins Univ Baltimore Md Dept Of Materials Science And Engineering, Title: Laser/Materials Interaction Studies for Enhanced Sensitivity of Laser Ultrasonic Systems. ,
Descriptive Note: Final rept. Apr 95-Sep 98, Personal Authors: Ehrlich, Michael J.; Spicer, James B.; Murray, Todd W.; Hurley, David H. , Report Date: MAY 1998, Pages: 350 PAGES, Contract Number: F33615-95-C-5223

KEYWORDS: optical initiation of explosives, initiators, detonators, laser initiation, explosive detonation, laser explosives

AF03-131 TITLE: Efficient Propulsion for Long Loiter Tactical Mini Air Vehicles

TECHNOLOGY AREAS: Air Platform, Space Platforms

ACQUISITION PROGRAM: Air Armament Center (AAC)

Objective: Develop efficient, light weight, and low cost power plant for small fixed wing long loiter aircraft

Description: The Air Force is interested in small, efficient and inexpensive power plants to propel miniature air vehicles (munitions) for extended periods of time. These air vehicles should be less than 200 pounds (including fuel, warhead, and seeker) and should be sized to be compatible with fighter internal carriage constraints. These flight vehicles should be capable of loitering for 12 hours or more while cruising at low subsonic air speeds and low altitudes. In order to achieve a low thrust specific fuel consumption at the altitude and velocity desired for this application, propeller driven reciprocating engines are attractive, but all power plants (e.g. fuel cells, solar/battery, etc.) meeting the performance requirements will be considered.

Phase I: Expectations for Phase I results include the following: analysis of applicable efficient power plant technologies, selection of an appropriate high efficiency power plant, and design of this power plant for Phase II fabrication and testing. The focus should be developing low thrust specific fuel consumption power plants for air vehicles operating under the constraints discussed in the description above.

Phase II: Expectations for Phase II results include the following: fabrication of the power plant designed in Phase I and ground testing of the engine via static thrust stand or other methods adequate to determine the performance of the power plant. The focus of Phase II efforts should be on fabricating the power plant designed in Phase I, demonstrating it, and verifying performance is achieved in accordance with the specifications in the description above.

Dual Use Commercialization Potential: Potential dual use applications include application of technology to enhance flight performance for existing civilian aircraft, search and rescue operations, police surveillance operations, and even application of technology in the radio control model aircraft industry.

Related References:

1. Scientific and Technical Information Network http://stinet.dtic.mil/str/index.html

2. "Lethal Unmanned Air Vehicle Feasibility Study", Green, John K, 18 SEP 1995, AD Number: ADA305574

3. "The Development and Operational Challenges of UAV and UCAV Airbreathing Propulsion", Cifone, Anthony; Parsons, Wayne, SEP 1999
AD Number: ADP010758

4. "Unmanned Areal Vehicles: Operational Implications for the Joint Force Commander", 12 Nov 94.
AD Number: ADA279420

5. "Quality Functional Deployment as a Conceptual Aircraft Design Tool", Tan, Rendell K., MAR 2000.
AD Number: ADA378471

KEYWORDS: reciprocating engines, fuel cells, low thrust specific fuel consumption, fuel efficient engines, efficient aircraft power plants, loitering aircraft, unmanned air vehicles

AF03-133 TITLE: High Lift-to-Drag Airframes for Long Loiter Tactical Mini Air Vehicles

TECHNOLOGY AREAS: Air Platform, Space Platforms

ACQUISITION PROGRAM: Air Armament Center (AAC)

Objective: Develop high L/D, light weight, high strength, low cost airframes for small, long loiter tactical mini air vehicles.

Description: The Air Force is interested in high lift-to-drag ratio, light weight, high strength airframes for tactical miniature air vehicle applications. These air vehicles should be less than 200 pounds (including fuel, warhead, and seeker) and should be sized to be compatible with fighter internal carriage constraints. These flight vehicles should be capable of loitering for 12 hours or more while cruising at low subsonic air speeds and low altitudes. The air vehicles will be air launched at high subsonic or supersonic speeds and will require deployable lifting surfaces. The long loiter times of these air vehicles may require non-conventional lifting surfaces which integrate technologies such as laminar flow control (passive, active or hybrid), active circulation and possibly buoyant surfaces. It is likely that high efficiency reciprocating engines will be used as the power plants for these aircraft. Coupled with the high efficiency engine, the air vehicle could alternate between powered and gliding flight to optimize loiter time and altitude. The airframe must be light weight to maximize payload weight, and high strength to survive the high speed air launch, and will require high strength, light weight materials. The airframe must also be low cost to maximize procurement numbers.

Phase I: Expectations for Phase I results include the following. Design stable airframe configurations with deployable lifting surfaces that will yield high lift-to-drag ratio values capable of meeting the performance specifications of the system. The focus should be on designing low cost, efficient airframes which optimize vehicle performance according to the constraints discussed in the Description above. Select the best design candidate for fabrication and testing in Phase II.

Phase II: Expectations of Phase II include the following. Build and wind tunnel test a scale model of the airframe designed in Phase I. Verify through aerodynamic analysis that the configuration is stable and will achieve the performance specifications discussed in the Description above. Make improvements to the design as necessary based upon the test results. Build and flight test a scale prototype of the final airframe as designed and tunnel tested in early Phase II.

Dual Use Commercialization Potential: Potential dual use applications include application of technology to enhance flight performance for existing civilian aircraft, search and rescue operations, police surveillance operations, and even application of technology in the radio control model aircraft industry.

Related References:
1. Scientific and Technical Information Network http://stinet.dtic.mil/str/index.html

2. "Lethal Unmanned Air Vehicle Feasibility Study", Green, John K, 18 SEP 1995, AD Number: ADA305574

3. "Integrating Automated Multi-Disciplinary Optimization in Preliminary Design of Non-Traditional Aircraft", Fidanci, Mehmet; Miller, Jeffrey R.; Strauss, Douglas J., MAR 2000. AD Number: ADA380252

4. "Unmanned Areal Vehicles: Operational Implications for the Joint Force Commander", 12 Nov 94. AD Number: ADA279420

5. "Quality Functional Deployment as a Conceptual Aircraft Design Tool", Tan, Rendell K., MAR 2000 AD Number: ADA378471

KEYWORDS: long loitering aircraft, unmanned air vehicles, high lift-to-drag airframes, light weight high strength aerospace materials, foldout lifting surface technology, miniature air vehicles.

AF03-134 TITLE: Adaptive Missile Airframe Technology

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: Weapons (WP)

Objective: Develop adaptive airframe structures for air-launched weapons operating in wide ranges of flight regimes

Description: A need exists to significantly increase capability in air delivered weapon systems. Traditionally each weapon design is optimized for a single mission such as short-range high-speed strike or long-range loitering attack. The optimization for a single mission usually takes the form of a specific, fixed airframe shape. In a first order effect, the overall airframe shape determines vehicle performance characteristics such as maneuverability, range, maximum velocity, and payload capability. A quick drop-off in these performance measures occurs when the weapon is employed outside its original operational envelope. Recent advances in smart materials, actuators, embedded sensors, and control systems have shown that it may be possible to create airframes that can achieve dramatic shape changes in flight. Thus, the overall goal of this program is to develop the enabling technologies required to build and test a weapon airframe capable of changing shape in flight. Desired controlled geometry changes include, but are not limited to, at least a 100% change in wing aspect ratio, wing area, and wing chamber. Shape changes in airframe cross-section design from low-drag to high-lift shapes are also desired.

Phase I: Determine the technological merit and feasibility of the innovative concept. A technical evaluation of the concept, an analysis of the concepts performance benefits, a description of a technical approach, alternative approaches, and associated risk factors should be performed. A demonstration of proof of principal through analysis, numerical simulation, and/or test may be appropriate.

Phase II: Build a prototype of the proposed concept. Demonstrate the merit of the concept through a combination of detailed analysis, digital simulation, hardware-in-the-loop testing, laboratory tests replicating operational conditions, and/or testing in actual operating conditions.

Dual Use Commercialization Potential: Demonstration of innovative shape changing airframe technologies for weapons with a large operating regime can lead to applications in other areas of the aerospace industry. Commercial high-speed transport aircraft and single stage-to-orbit vehicles are two examples of systems that will be required to operated over a large range of operating conditions.

Related References:

1. Kudva, J. N., et al, "Overview of the DARPA/AFRL/NASA smart wing phase II program," Proc. SPIE Vol. 4332, pp. 383-389, Smart Structures and Materials, 2001

2. Henderson, J. A., et al, "Integrated wing design with adaptive control surfaces", 42nd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Seattle, Washington April 16-19, 2001, AIAA 2001-1428

3. Crawley, E. F., "Intelligent structures for aerospace: a technology overview and assessment", AIAA Journal, Vol. 32, No. 8, August 1994, pp. 1689-1699

KEYWORDS: smart structures, smart materials, morphing structures, smart wing, shape memory alloys, piezoelectric actuators

AF03-137 TITLE: Free Flight Sensor

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Weapons (WP)

Objective: Sense a post launch environment to provide an arming input signal for powered or non-powered guided weapons.

Description: Conventional weapon fuzes must sense two independent environments associated with the launch and free flight of the weapon. The sensing of these two environments is necessary to assure weapon system safety. Current practice with non-powered, free fall weapons is to utilize a lanyard (or similar device) to ensure release from the aircraft and a wind-powered generator to sense airflow and provide electrical energy to the fuze. This scheme works well for ballistic free fall weapons with fairly well known flow fields. With newer laser, electro-optical and inertial guided weapons, the ballistic trajectory can be significantly modified by the guidance and control system, resulting in undefined airflow. The problem is aggravated by the large number of warhead/guidance kits and delivery condition (200 kias to Mach 1.2 with altitudes to 40,000 ft) combinations. The number of combinations makes comprehensive detailed airflow calculations, or testing, cost prohibitive. The result has been field failures under certain of the above combinations. A simple reliable remedy would be to utilize weapon system power (battery) for the fuze energy source, but the problem of sensing a post launch environment would be introduced. Thus, the need exists for some type of post launch environmental sensor that would be flexible enough both in performance and configuration to properly function in a large number of warhead and guidance system combinations. Novel airflow sensors, barometers, and programmable Micro-Electromechanical Systems (MEMS) inertial sensors may merit consideration. Any environment that is associated with launch and/or free flight may be a candidate for monitoring (sensing) by the fuze for inputs to determine free flight and/or safe separation of a weapon from an aircraft.

Phase I: The goal of Phase I should be the development of a feasibility concept(s). The feasibility concept development should include analytical evaluation of the proposed concept(s) performance under the widely varying release and fight conditions as well as eventual physical configuration estimates and the location constraints for typical weapon system combinations.

Phase II: This phase should end at prototype demonstration of the concept(s) developed in Phase I. This demonstration should indicate that the proposed concepts can sense the launch environment and can be accomplished by laboratory evaluations that statically emulate a dynamic launch environment.

Phase III: The goal of this Phase should include the design, fabrication, and demonstration test of the final prototype. The testing required/desired may be highly dependent upon the concept proposed. The testing should be adequate to demonstrate that the concept has the potential to satisfy a large number of the possible weapon system configurations and delivery conditions. Delivery of units for eventual Air Force testing is highly desirable.

Dual Use Commercialization Potential: The eventual dual use potential of this effort is dependent upon the concept proposed. For example, novel airflow or barometric sensing could be applicable to commercial and private aircraft. Inertial types could be applicable to automobile navigation while some proximity concepts could be applicable to automotive crash avoidance systems.

Related References:
1. DoD Dictionary of Military Terms (http://www.dtic.mil/doctrine/jel/doddict)
2. The Ordnance Shop (http://www.ordnance.org/gpb.htm)
3. MIL-S-28756B, SWITCH, AIR AND LIQUID FLOW, SENSING GENERAL SPECIFICATION
4. Chakravarthy, Sukumar R.; Szema, Kuo-Yen, "Computational Fluid Dynamics Capability for Internally Carried Store Separation," SC71039TR (ADA253671)
5. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Weapon Safe Separation, Trajectory Monitoring, Airflow Sensing, Altitude Sensing, Bomb Dynamics, General Purpose Bomb Fuzes

AF03-138 TITLE: Bistatic Altimeter Concept

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: Weapons (WP)

Objective: Develop RF sensor to provide accurate altitude information for a flying vehicle using passive sensing.

Description: Most of the munitions currently used, whether GPS or inertially guided have non-optimal targeting performance with shallow glide slope angles. The errors asssociated with shallow glide slope angle trajectories in the altitude domain prevent the guidance subsystem from minimizing the Circular Error Probability (CEP) of the munition. If an active altimeter were added to the munition, the associated eletronics volume and cost would be too great for implementation, not to mention the position of the munition being advertised by the active radiation. For this reason, most enertially or GPS guided munitions employ high angle of attack trajectories for optimal precision targeting and minimal collateral damage.

This topic will investigate concepts of exploiting RF signals with a passive RF sensor to attain precise altitude measurements on a flying vehicle. A passive sensor requires only an antenna and a receiver system that can be made very small, inexpensive, and with low power requirements. Algorithms to exploit this passive sensor technique will be explored.

Phase I: An innovative concept formulation and design will be performed for developing the prototype passive RF sensor. Unique mathematical models will be derived and algorithm requirements for the prototype sensor will be documented.

Phase II: Construct and deliver a prototype passive RF sensor based on the Phase I concept design will be accomplished. This will include all hardware, algorithm development, integration and test of the hardware and software products.

Dual Use Commercialization Potential: This passive RF altimeter could be use on commercial and private aicraft as a backup or a primary altemeter instrument for navigation. The use of the passive sensor would provide cost savings in power and weight, due to the fact that there is no transmitter requirement.

Related References:
1. Satellite Selection Criteria During Altimeter Aiding of GPS, Author: Stein, B. A., Navigation, v32n2 p149-157 Summer 85.

2. Pulse Propogation and Bistatic Scattering, Author: Ziomek, Lawrence J., 26 Oct 2001, Master's Thesis.

3. The Validation and Application of a Bistatic Two-Scale of Surface Roughness Scattering Model, Authors: Papa, Robert J.;Woodworth, Margaret B., Interim scientific rept. Nov 88. DTIC Report Number:RADC-TR-88-269 (ADA223231)

KEYWORDS: GPS, passive RF, bistatic sensing, change detection sensor, altimeter, GPS timing

AF03-139 TITLE: Precise Guidance--No Seeker

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: Weapons (WP)

Objective: Develop approaches implementing precise guidance against ground movable targets for air-launched munitions without employing seekers.

Description: Current precision guided weapons utilize GPS/INS and seeker technologies for guidance to ground targets. GPS/INS systems work by acquiring position and velocity information and maneuvering to given target coordinates entered before release. If seeker technology is used, target-tracking techniques are employed to guide to the final target. The need to precisely attack fixed/moveable targets has come to the forefront in the most recent conflicts. Seekers bring high accuracy for moving/moveable targets but also much higher cost and greater mission planning, power, and cooling requirements. The ability to attack this class of targets without the expense and issues associated with seekers is desirable. We seek innovative concepts for precision guidance against fixed/moveable ground targets for implementation in air-launched munitions.

Phase I: Design a concept for the need to support air-launched precise target attack on fixed/ground movable targets with no seeker. This effort should capitalize on or augment GPS/INS to give all-weather guidance capability without degradation to the Circle Error Probable (CEP) of a 3-meter CEP class weapons system. Examples might include, the use of GPS pseudolites to send augmented data to a weapon, or a weapon data link to update target coordinates. Emphasis on near-term application of affordable technology is key. Current aircraft or weapon technologies adapted to this type of warfare will be given preference. Concepts that use technologies that can be supported by current infrastructure are good as well. Concepts that use new (but affordable) technologies that will require some amount of new infrastructure are welcome.

Phase II: Construct and demonstrate the operation of a prototype of the concept from Phase I, to include a brass board fabrication and test. The offeror shall develop viable demonstration cases either in collaboration with the government or private sector. If successful, the prototype could be transitioned to one or more air-launched weapon technical insertion programs of direct interest to this organization.

Dual Use Commercialization Potential: Follow-on activities are expected to be aggressively pursued by the offeror. This will include seeking opportunities to insert the concept developed into air-to-ground weapon systems. Commercial benefits will depend on the concept approach, but may include opportunities in the telecommunications or commercial navigation industries.

Related References:
1. Turner, A. "Time-Critical Targeting for the CINC," Naval War College, February 2001 (ADA389611)
2. Licata, W. "INS/GPS for Strike Warfare Beyond the Year 2000," RTO Lecture Series 221 September 2000(ADP010406)
3. Almonte, J. "'Rapid Targeting Triad' Against the Mobile Threat: An Evolutionary Concept," Naval War College, February 2000 (ADA378511)
4. Searle, D. "Rapid Targeting and Real-Time Response: The Critical Links for Effective Use of Combined Intelligence Products in Combat Operations," December 1996, (ADA31888)

5. J.L. Tuohino, M.G. Farley, R.R. James, "Military Pseudolite Flight Tests results," ION GPS 2000, Salt Lake City, UT, Sept 19-22 2000.

KEYWORDS: Precise Guidance, moving target identification, datalinks, Global Positioning System, mobile targets, tactical data systems

AF03-140 TITLE: Airframe Materials for High Speed Tactical Missiles

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Weapons (WP)

Objective: Develop low cost materials and fabrication technologies for high-sustained speed and high-g maneuvering missiles.

Description: A need exists to significantly increase our capability in air superiority missile systems. Of particular interest is developing technologies that would allow a single missile to perform the roles currently performed by a suite of missiles. The current suite of air superiority missiles include short range air-to-air missiles for within-visual-range combat, medium range air-to-air missiles for beyond visual range combat, and medium range air-to-surface missiles to defeat enemy air defense systems. In addition to having a single missile capable of filling all the above roles, there is a desire for a general increase in the performance capability when performing each role (for example, to vastly increase the range capability of future missiles while keeping the time to target low). Meeting all these requirements will place a large burden on the airframe design. Long-range requirements drive the external vehicle shape to high lift-to-drag airframe configurations. Unfortunately, these configurations are not well suited for high-g maneuvering. The low time-to-target requirement means the missile will need to accelerate quickly and then maintain high-speed flight. These requirements will drive the airframe configuration to be lightweight yet capable of retaining very high strength while at high temperature. Standard high temperature metal alloys such as nickel-steel or columbium-based alloys have too high a weight penalty to be used. Existing coated carbon matrix composite, ceramic, or graphite-polyamide materials have the potential to meet the needs of advanced missiles; however, innovative advances must be made to make these materials affordable for tactical missile use. Whatever material is pursued, it must be suitable to low-cost processing and part manufacturing.

Phase I: Identify and define candidate materials and/or material processing techniques for high strength applications at temperatures above 1200 degrees F for 10-minute flight durations. The minimum desired ultimate tensile strength at temperature is 130 ksi. The desired material density is less than .25 lbs/cu in. Materials shall be evaluated through analysis and/or test of small specimens.

Phase II: Demonstrate the benefit of the material concept generated in Phase I by fabricating, processing, and characterizing an airframe structural component or subcomponent such as a fuselage section, wing, or control fin.

Dual Use Commercialization Potential: Demonstration of a lightweight, high strength, high temperature material suitable for structural applications will have a large variety of uses in the aerospace industry. Such materials can be used for aircraft and missile fuselage, wing, and tail surfaces. Potential applications would also be in high temperature regions of commercial aircraft engines and commercial space launch vehicles.

Related References:
1. Fleeman, E.L., Licata W. H., Berglund, E., "Technologies for future precision strike missile systems,", NATO Research and Technology Organization Lecture Series, RTO-EN-018, June 18-29, 2001. (ADA394520)
2. Jane's air-launched weapons, 1999, Lennox, Duncan, Ed., Jane's Information Group, Coulsdon, Surrey, UK

KEYWORDS: high temperature materials, carbon-carbon composites, polymer-matrix composites, high speed missiles, high speed aircraft, missile airframe

AF03-141 TITLE: Rapid Target Failure Modes, Effects and Criticality Analysis

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Weapons (WP)

Objective: Establish approaches to rapid determination of the vulnerability of a complex threat target to conventional weapon effects.

Description: All targets are composed of an arrangement of critical components and sub-components that function in unison to carry out the targets intended mission. To perform an assessment of the effectiveness of US weapons against a target, one must model the vulnerability of the target to the weapon effects. This requires modeling of the critical components with enough fidelity (in size, orientation, location, material characteristics, etc.) so that a reasonable representation of the overall target vulnerability can be determined. These components and systems are expressed in terms of a deactivation diagram or Failure Analysis Logic Tree (FALT) (commonly referred to as a "fault tree"). The fault tree defines the functional interrelationships between all critical target components. Unfortunately, the vast number of target type, classes, and configurations has kept the weapon effectiveness community from the capability to assess but a small portion of the total number. The primary reason for this is that the modeling of each target is time consuming. Even after the geometric model is complete, the FALT model must be generated to allow the analyst to assess the effect of damage to some component of the target on its function or mission. We seek a novel way to reduce this time-consuming process to allow a rapid generation of a target and its functional logic based on the current library of targets, their components, and sub-components. The approach must provide a plug-and-play ease of use so a user can select components and arrange them such that virtually any target could be generated and the FALT generated automatically.

Phase I: Develop an approach to generating generic critical targets components and sub-components and easy ways to arrange these components such that when arranged appropriately form a viable representation of a wide class of target types. Show how this approach is feasible and how it would automatically produce the appropriate interconnectivity or FALT to allow the assessment of the vulnerability of a target to weapon effects.

Phase II: Implement and demonstrate the conceptual approach developed during Phase I using an acceptable system of critical components or assembly of sub-components that could be representative of a target. The government will assist in identifying an appropriate demonstration case if desired by the contractor.

Phase III Dual Use Applications: The tools and approach developed in Phase II will be implemented on specific military system selected in collaboration with the Government sponsor. Additionally, follow-on activities are expected to be aggressively pursued by the offeror, namely in seeking opportunities to integrate this approach into non-military applications. Commercial benefits include the ability to quickly assess the vulnerability of generic commercial buildings, equipment, aircraft, manufacturing, ships, etc. to damage from explosions (gas, dust, chemical reaction, terrorist attack, etc.), or other damage mechanisms. A set of generic critical components found in these items when arranged would represent the item and FALT generation would allow quick assessment. Many of the components would also be similar to those developed in the PHASE II.

Related References:
1. Durfee, G. L. ;Kinsler, R. E. ;Braerman, W. F. ; "Sensitivity Analysis of the PKHDOC Component Vulnerability Methodology", Report Number: ARBRL-MR-02995, FEB 1980, AD Number: ADA083291
2. Losie, Lawrence D.; "Examination of the Distribution of the Number of Component-Damage States", Report Number: ARL-TR-615, NOV 94, AD Number: ADA286241
3. Deitz, Paul H.; Mermagen, William H., Jr.; Stay, Paul R.; "An Integrated Environment for Army, Navy and Air Force Target Description Support", Report Number: BRL-MR-3754, MAY 89, AD Number: ADA209667
4. Roach, Lisa K.; "Fault Tree Analysis and Extensions of the V/L Process Structure", Report Number: ARL-TR-149, JUN 93, AD Number: ADA266080
5. Burdeshaw, Mark D.; Abell, John M.; Price, Scott K.; Roach, Lisa K.; "Degraded States Vulnerability Analysis of a Foreign Armored Fighting Vehicle", Report Number: ARL-TR-299, NOV 93, AD Number: ADA273416

KEYWORDS: Fault tree, FALT, Failure Modes Effects, Criticality Analysis, Vulnerability Assessment, Component Vulnerability

AF03-142 TITLE: Revolutionary Beam Steering Technology for Imaging Laser Radar

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: Weapons (WP)

Objective: Develop revolutionary beam steering technologies for imaging laser radar munitions seekers.

Description: This topic solicits proposals to develop revolutionary technologies to enhance imaging laser radar (ladar) for munitions seekers. Specifically, advances are needed in non-mechanical or micro-mechanical beam steering technologies.

Current ladar seekers require mechanical gimbals to raster scan a laser across a field of view (FOV) to generate a three dimensional image and to aim the FOV of the seeker in order to track a target. The gimbals add significant weight, size, complexity and cost to the seeker. Any beam steering system should be capable of scanning a beam over a 30° x 30° total field of regard. Within that field of regard, a ladar system would use either a raster scanned laser and detector or a staring array of detectors to generate an image up to 6° x 6°. For raster scanned ladar, in order to generate images at an acceptable frequency, a scanning system is required that can rapidly steer a laser through up to 6° x 6° with scan speeds up to 20 rad/sec. The high scan speeds are required to scan lasers with repetition rates up to 50 kHz to generate images with 0.1 to 0.4 mrad per pixel resolution. The scanning system must function for laser beams in the near or mid-infrared with laser fluxes on the order of a few tens of kW/cm^2. For staring array seekers, scan speeds up to 1 rad/sec would be sufficient to steer the field of view of the detector array through its total field of regard, but the steering system must function for lasers in the near infrared (1 to 2 microns) with laser fluxes on the order of a few MW/cm^2. The steering system must also have a relatively large active area to reflect laser radiation collected through a 5 inch aperture onto an array of detectors up to 1 inch square.

Proposed solutions should be suitable for a laboratory breadboard demonstration for raster scanned and/or staring array ladar, but should address eventual integration into a seeker suitable for a munitions application. Solutions should address a complete laser radar system design, or at least a conceptual implementation of the proposed component into a complete imaging laser radar system.

Phase I: Phase I of this project should investigate the performance of the proposed system through detailed modeling and experimentation to demonstrate critical elements of the design. The investigation results would be incorporated into a detailed prototype system design to be reported at the end of Phase I.

Phase II: Phase II of this project would involve the construction and delivery of a prototype system based upon the design investigated in Phase I.

Dual Use Commercialization Potential: A wide range of commercial and military applications exist for the technology addressed in this topic, including communications, manufacturing, and remote sensing. Commercial laser radar applications include geographic surveying, industrial monitoring, adaptive cruise control and collision avoidance, and automated aircraft landing and docking of space vehicles. Military laser radar applications include seekers for autonomous munitions guidance, surveillance and reconnaissance sensors and precision targeting systems.

Related References:
1. C. G. Bachman, “Laser Radar Systems and Techniques,” Artech House, Boston, 1979.

2. A. Jelalian, “Laser Radar Systems,” Artech House, Boston, 1992.

3. DTIC Report #: AFIT/DS/ENG/98-01

4. DTIC Report #: SC5545.FR

5. McManamon, Paul F., et. al., "Optical Phased Array Technology," Proceedings of the IEEE, Vol. 84, No. 2, February 1996.

KEYWORDS: laser radar, ladar, laser sensor, non-mechanical beam steering, laser beam steering, ladar tracking, beam pointing

AF03-143 TITLE: Munitions Research

TECHNOLOGY AREAS: Weapons

Objective: Develop innovative concepts in areas associated with air-deliverable munitions and armaments.

Description: The Air Force Research Laboratory Munitions Directorate's mission is to develop, integrate, and transition science and technology for air-launched munitions for defeating ground-fixed, mobile/re-locatable, air and space targets to assure the preeminence of US air and space forces. The purpose of this topic is to give the potential Small Business/Offeror an opportunity to submit their unique ideas, which are not covered/mentioned in other Munitions Directorate topics, that they feel will contribute to the overall mission of the Directorate.

a. The Assessment and Demonstrations Division is seeking new and innovative ideas for future weapon integrating concepts, such as a persistant area dominance weapon, low cost miniature cruise missile, counterproliferation weapon, microbot munitions, functional defeat of hard targets, and Bomb Damage Indication/Battle Damage Assessment (BDI/BDA. Technologies under consideration include weapon design, innovative flight controls and range extension technologies, compressed carriage and dispense technologies, micro technologies, munition borne and munition deployed BDI/BDA sensor, processor, and transmitter technologies, and integrated subsystem techniques. Modeling and simulation tools of interest include high-fidelity physics-based codes for warhead design and penetration analysis, engineering-level tools for weapon/target interaction analysis, and system-level analysis for theater- level modeling. New concept and innovative tools are sought for system-level evaluations, the prediction of functional relationship of fire and/or blast effects on fixed structures, and dispersion of chemical/biological neutralization agents in a high-temperature environment.

b. The Advanced Guidance Division seeks new concepts in areas associated with closed-loop guidance of autonomous munitions including inertial sensors, antijam GPS (AJGPS), and terminal seekers, including electro-optical (I2R and LADAR), millimeter-wave, and synthetic aperture radar seeker technology, and the components thereof, and the signal/image/data processing used in such areas. Algorithm/software concepts of interest include (1) guidance software, including guidance laws, estimators, autopilots, and AJGPS software, (2) innovative signal and image processing algorithms for use within autonomous target acquisition (ATA) applications, and (3) operations/functions associated with the ATA process involving noise elimination, detection, segmentation, feature extraction, classification, and identification. Algorithms capable of processing/fusing multi-sensor data are of interest. Fundamentally new approaches to closed-loop autonomous guidance based on biomimetic principles are of particular interest.

c. The Ordnance Division is seeking new and innovative ideas/concepts to support the development of advanced warheads, fuzes, and explosives for use in air-delivered conventional munitions to defeat ground, mobile, air targets, as well as above-ground and buried structures. Technologies developed should ultimately result in new and innovative components which are needed to meet the complex future munitions requirements for general-purpose bombs, penetrating warheads, submunitions, safe-arm-fire devices, explosive detonators, explosives and advanced energetic materials, and devices for collecting data to be used in warhead design and analysis. Technologies for defeating weapons of mass destruction, including biological and chemical agents, and/or access denial to stored weapons, are of interest.

Phase I: Determine the technological or scientific merit and the feasibility of the innovative concept.

Phase II: Produce a well-defined prototype product or process.

Dual Use Commercialization Potential: a. Commercial dual-use applications for innovative flight vehicle technologies could improve air vehicle performance, as would air foil products, i.e., wind turbines, turbomachinery, etc. Simulations of effects would reduce test costs and provide greater capability for safety officials and insurance underwriters to assess associated hazards. Improved simulation models could benefit commercial building demolition, safety-related assessments, auto safety research, explosives research, mining, drilling, and a wide range of product analysis and evaluation activities.

b. Commercial dual use applications for these guidance technologies include sensors, processors algorithms applicable to medical imaging, commercial aviation (adverse weather penetration), remote sensing and surveillance.

c. Commercial dual use application for these ordnance technologies include facility/plant security and monitoring, high speed wireless data transmission, micro-electrical mechanical devices for controls and collision avoidance, high powered energy storage devices (capacitors and batteries) and environmentally responsible recycling of energetics and other materials.

Related References: AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: demonstration, assessment, airframe, terminal guidance, autonomous, guidance, automatic target recognition, precision guided munitions sensor technology, seeker technol

AF03-144 TITLE: <u>Readout Integrated Circuit Development for Staring Focal Plane Array Laser Radar (LADAR)</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: Develop innovative circuit solutions to provide range and intensity information in an FPA-based ladar system.

Description: This topic will request proposals to address the development of advanced read out integrated circuits (ROIC) suitable for integration with a large focal plane array (FPA) of optical detectors. The FPA-ROIC combination will serve as the optical receiver in a laser radar system. Some of the key performance parameters associated with the development of the pulse capture and processing technique implemented in the ROIC are range resolution, range accuracy, dynamic range (both in range and intensity measurements), and unit cell size. The parameters should definitely be addressed in the offeror's proposal. Current laser radar systems are focusing on eye-safe laser radar operation (operating wavelengths longer than 1.5 micron) providing less than 15cm range resolution at a nominal operating range of two kilometers, and providing sufficient resolution.

Phase I: Phase I of this project should investigate the performance of the proposed read out integrated circuit through detailed modeling, and experimentation to demonstrate critical elements of the design. The investigation results would be incorporated into a detailed prototype system design to be reported at the end of Phase I. Small mock-up prototypes may be produced.

Phase II: Phase II of this project would involve the construction and delivery of a prototype system based upon the design investigated in Phase I.

Dual Use Commercialization Potential: A wide range of commercial and military applications exists for the technology addressed in this topic, including medical applications, communications, manufacturing, and remote sensing. Commercial laser radar applications include geographic surveying, industrial monitoring, adaptive cruise control and collision avoidance, and automated aircraft landing and docking of space vehicles. Military laser radar applications include surveillance and reconnaissance and precision targeting systems.

Related References:

1. C. G. Bachman, “Laser Radar Systems and Techniques,” Artech House, Boston, 1979.

2. A. Jelalian, “Laser Radar Systems,” Artech House, Boston, 1992.

3. Leader, J. C., "Laser Radar Analyses", DTIC AD Number: ADA133295, JUL 1983

KEYWORDS: pulse-capture electronics, laser radar, direct detect, dynamic range, nanosecond-level laser pulses, photoconduction

AF03-145 TITLE: Micro-Encapsulation Of Nanometric Reactive Particle Mixtures With Explosive Cores

TECHNOLOGY AREAS: Materials/Processes, Weapons

Objective: Produce microencapsulated composite particles having explosive cores surrounded by nanometric reactive powder mixtures.

Description: Mixtures of nanoscale reactive particles now can be used to replace or enhance traditional energetic materials. However, the powders can be difficult to work with. Incorporation of bare nanoscale powders in traditional cast explosive or propellant formulations presents numerous challenges. To achieve full potential, the materials need to be homogeneously and uniformly dispersed within the casting matrix, and the average distance between reactive particles must be small. When raw nanoscale particles are added to cast formulation mixes, the high specific surface area of the nano-powder leads to unmanageable mix viscosity. One approach to overcome such problems would be to first encapsulate mixtures of the nano-powders, at the multiple-micron scale. Furthermore, by also including explosive material within the capsules, a new capability to control energy release kinetics can be achieved. Methods to encapsulate nanoscale and explosive materials so that they can be easily incorporated into cast formulations, and that react to release energy over a time period that can be controlled through design of encapsulation material, capsule content distribution, and capsule size are to be developed in this research. It will also be important to develop techniques to minimize void content within the capsules, i.e., to maximize solids loading.

Phase I: In Phase I, requirements for explosive formulation and reaction kinetics control will be analyzed to identify approaches. Candidate approaches will be demonstrated, and sample products characterized (size, content, content distribution, small scale safety tests, capsule crush strength). Sample materials of sufficient quantity for use in cast formulations will be produced. Working with AFRL/MNME, highly-loaded test cast formulations will be produced and energy release characterized.

Phase II: In Phase II, all key elements required for scale-up of best candidate process for production of reaction-rate controlled encapsulated nanometric energetic powders would be defined and demonstrated. Use of these materials in large-batch cast formulations using current state-of-art processing equipment will be demonstrated. The reaction initiation and energy release performance of charges formulated from encapsulated materials designed for control of the energy release rate will be documented as a function of encapsulation variables.

Dual Use Commercialization Potential: Several large potential markets exist for the enhanced energetic materials that will result from this research. The encapsulation techniques developed will allow design of more energetic explosives that release their energy with more control, and over longer periods. These attributes are very desirable in all civil blasting applications. For construction blasting, longer duration release can reduce hazardous fly-rock and ground vibration. In surface mining, the higher energy and longer duration energy release will provide improved overburden heave and ore removal, as well as reduced ground vibration and fly-rock. The improved formulations will also benefit underground mining. These encapsulated energetic materials will also be useful in solid rocket propellants, a large and growing market.

Related References:
1. Dixon, George P.; Martin, Joe A.; Thompson, Don; “Lead-Free Percussion Primer Mixes Based on Metastable Interstitial Composite (MIC) Technology,” DTIC AD Number: ADD018970

2. Gonsalves, K.; "Nanostructured Bearing Alloy Studies," DTIC AD Number: ADA299199

3. Garg, A. K.; De Jonghe, L. C.; "Microencapsulation of Silicon Nitride Particles with Yttria and Yttria- Alumina Precursors," J. Mater. Res.; 5 (1), 136-42, 1990. Materials Research Society: Pittsburgh, Pennsylvania

4. Mort, Paul R.; Riman, Richard E.; "Reactive Multicomponent Powder Mixtures Prepared by Microencapsulation: Pb(Mg(1/3)Nb(2/3))O3 Synthesis", J. Am. Ceram. Soc.; 75 (6), 1581-6, 1992. American Ceramic Society: Westerville, Ohio

5. Baldeschwieler, John D.; "Development of Microencapsulation Techniques," DTIC AD Number: ADA185019

KEYWORDS: micro-encapsulation, micro-balloons, nanometric reactive materials, explosives, prill, metastable interstitial composites, nanocrystalline metals, reactive powders

AF03-146 TITLE: Material Characterization of Chemical and Biological Agents

TECHNOLOGY AREAS: Chemical/Bio Defense

Objective: Develop a Toolkit for determining the Equation of State and Shock Response Models of Mixtures and Liquid-Based Suspensions.

Description: Many biological agents are not stored or weaponized in "pure" form. Instead they are stored in the form of mixtures, or liquid-based suspensions. That is to say, these agents consist of some liquid material combined with growth medium. The active component of the agent is "mixed" in with this base. The final agent product may exist in the form of slurry, a liquid/particle mixture. This material has solid-like particles suspended within a bulk fluid. Given the nature of the suspended solid, these agents may behave very differently from regular liquids. The inter-particle bonding may cause an anisotropic response to stresses applied to the material. Moreover, for settling mixtures, the nature of the material equation of state may change drastically from one point in the fluid to another. This may be true particularly for stratified mixtures. In many cases such agents are stored while under active stirring. An important area of research would entail experimentation to determine an understanding of the properties of these materials and then to develop reliable and robust models for these materials. This lack of knowledge sometimes leads to unexpected results in experiments and prohibits the accurate modeling of experiments. For example, the viscosity, surface tension, and vapor pressure as a function of temperature are essential in the modeling of aerosolization of agents released during an attack. The knowledge gained from this work would be most useful in the form of a toolkit in which data obtained from experiments can be translated into the relevant equation of state and shock response models.

Phase I: Conceptualize and design an innovative method of collecting experimental data so that the relevant parameters will be measurable as a function of temperature and pressure. The specific temperature and pressure range extends from room conditions to those experienced during the penetration of a container projectile or the explosion of an energetic material warhead. Define and determine the mathematical framework for studying the properties of non-Newtonian fluids, mixtures, and slurries.

Phase II: Determine a procedure for identifying suitable simulant materials. Finalize the selection of simulate materials. Produce prototype experimental equipment (if needed) and conduct experiments to determine needed property data. Construct the final EOS and shock response models. Perform all needed mathematical modeling to turn the conceptual models into validated algorithms, and provide a practical implementation of the models and procedures in the form of a toolkit.

Dual Use Commercialization Potential: The industrial processes for the commercial biotechnology industry and a biological warfare facility are nearly the same. The material characterization toolkit resulting from this SBIR would be very valuable in the commercial biotechnology industry.

Related References:

1. Alibek, Ken, “Biohazard : The Chilling True Story of the Largest Covert Biological Weapons Program in the World-Told from the Inside by the Man Who Ran It Towards a Coherent Strategy for Combating Biological Weapons of Mass Destruction,” Random House, 1999.
2. Volpe, Philip, “Towards a Coherent Strategy for Combating Biological Weapons of Mass Destruction,” (ADA308957).
3. Seebaugh, William R.; Ganong, Gary P., “Summary of Collateral Effects Experiments Conducted During Fiscal Year 1996,” LAT990075 (ADA382603).
4. Schowalter, Walter, “Mechanics of Non-Newtonian Fluids,” Pergamon Press, 1978.
5. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Biological Agent, Non-Newtonian, Mixtures, Equation of State, EOS, Fluid Dynamics

AF03-147 TITLE: Modeling Damaged Agent Filled Containers with Incompressible Turbulent Flow and Moving Boundaries

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

Objective: Develop Techniques for Modeling Damaged Agent Filled Containers with Turbulent Flow and Moving Boundaries

Description: Current tools for assessing dynamic, unsteady incompressible flow fields are insufficient for meeting the needs of the Counter Proliferation community. The incompressible flow problem is a core component of the hydrodynamic ram problem, the problem concerned with the breach of liquid filled containers by impacting projectiles. By coupling the code resulting from this research effort with a structural response code, one can obtain a properly formulated set of initial conditions for a liquid expulsion, jetting and aerosolization code. Research emphasis is now focusing on incompressible flow fields, finite in extent and characterized by three-dimensional turbulence. The wind tunnel analogy long employed by CFD is no longer an acceptable assumption. Three-dimensional solid objects must now unsteadily move through a viscous flow field. That is to say that an object penetrating a fluid mass must be allowed to decelerate and change its orientation in time. In this case, the freestream is truly unsteady, and the mesh must move with the body. Research has shown that most current algorithms are locally limited to second-order accuracy. Moreover, contemporary CFD algorithms are truly designed to support the assumption of steady flow. Given the unsteady nature of our problems of interest, these assumptions are invalid and must be lifted. The line of research that holds the most promise in overcoming these limitations is that of compact numerical schemes. Compact numerical schemes allow the flow solution to evolve seamlessly within each grid cell and along the cell boundaries. Compact schemes calculate and store information in a continuum within each grid cell. This approach has two major advantages. First, the solution in each cell is generated as a continuous function. Secondly, it can be shown that the quoted order of accuracy for the compact scheme is indeed the true order of accuracy. One should not confuse compact schemes with compact operator schemes. Compact schemes may relax the requirements for grid resolution throughout the flow field and particularly in the boundary layer. These schemes' ability to resolve steep viscous gradients resides in the order of functional basis used to represent the solution in each flow cell. These schemes combine the best attributes of finite element and finite volume techniques.

Phase I: Conceptualize and design an innovative compact scheme for a simple three dimensional geometry using incompressible laminar viscous flow and a liquid equation of state.

Phase II: Using the results from Phase I, extend the algorithm to include an appropriate turbulence model, interface tracking, body dynamics, moving grid boundaries, and all other enhancements necessary to demonstrate full three-dimensional calculations of a projectile moving through a fluid mass. Provide a plan for practical implementation of this capability for the problem discussed in the Description section of the topic write-up.

Dual Use Commercialization Potential: The results of this SBIR would be useful for modeling industrial processes involving liquids, and liquid transport systems.

Related References:
1. Turek, Stefan, "Efficient Solvers for Incompressible Flow Problems," Springer-Verlag, 1999.

2. Wilcox, David, "Turbulence Modeling for CFD," DCW Industries, July, 1998.
3. Shu, Chi Wang., "High Order Numerical Methods for Long Time Solutions with Discontinuities," (ADA395323).
4. Mautner, T. S., "Confined Two-Phase Incompressible Flows," (ADA305763)
5. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Incompressible, interface tracking, numerical, fluid dynamics, turbulence, unsteady

AF03-148 TITLE: Creative Robots to Defeat Deeply Buried Targets

TECHNOLOGY AREAS: Materials/Processes, Weapons

Objective: Develop Creative Self-learning Multi-Sensory Autonomous Reconfigurable Objects that represent miniature and micro robots.

Description: Determine the feasibility of Creative Self-learning Multi-Sensory Autonomous Reconfigurable Objects. There are numerous efforts underway to develop miniature and micro robotic technology to defeat, disrupt or disable deeply buried target. Digital simulations using Creative Self-learning Multi-Sensory Autonomous digital objects will be a useful tool for CONOPs developments of robots attacking deeply buried targets. Recent advances in creative, self-training artificial neural network object technology have pave the way for creating Creative Self-learning Multi-Sensory Autonomous digital objects. Objects of this nature can be duplicated to create a swarm of robot objects, which can be used in a digital simulation for attacking deeply buried targets. The objects would also be useful in developing alternative control systems for miniature and micro robots.

Phase I: Generate requirements and determine the feasibility of Creative Self-learning Multi-Sensory Autonomous Reconfigurable Objects.

Phase II: Refine requirements for Creative Self-learning Multi-Sensory Autonomous Reconfigurable Objects. Develop an object and demonstrate its capability. Show how the objects can be used in high fidelity simulations to support the CONOPs development for using robots to defeat, disrupt or disable deeply buried targets.

Dual Use Commercialization Potential: Technology developed on this program will have application for commercial and military robots and consumer toys.

Related References:
1. Integration of an Image Hardware/Software System into Autonomous Robot, Author: Kisor, John C., AD Number: ADA294480, Source Code: 251450, Report Date: MAR 1995

2. Automated Cartography by an Autonomous Mobile Robot, Author: Merrell, Mark L., AD Number: ADA361540, Source Code: 251450, Report Date: MAR 1999.

3. The Local Motion Planning for an Autonomous Mobile Robot, Author: Yun, Seok J, AD Number: ADA304359, Report Date: SEP 1995.

4. Intelligent Sensor-Based Manipulation with Robotic Hands, Author: Allen, Peter, AD Number: ADA357655, ProxyURL/Handle: http://handle.dtic.mil/100.2/ADA357655, Report Date: 14 DEC 1998.

5. A Biologically-Inspired Autonomous Robot, Author: Beer, Randall D., AD Number: ADA289446, ProxyURL/Handle: http://handle.dtic.mil/100.2/ADA289446, Report Date: 27 DEC 1994.

KEYWORDS: miniature robots, micro robots, Self-learning, creative robots, simulation, CONOPs, Multi-Sensory

AF03-151 TITLE: Soft Landing Capability For 1000 lb Dispenser

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Weapons (WP)

Objective: Develop a soft landing munitions dispenser providing safe, accurate delivery of supplies to remote areas.

Description: This R&D effort will explore and develop technologies for lightweight, compact retarders and cushioning devices to be integrated with a 1000 lb class dispenser. This capability will allow the resupply of remote and/or isolated military units and could be accomplished without exposing aircraft to hostile ground fire or ground troops to high velocity hardware impacts. With low altitude deployment of a deceleration/retarding device, the delivery could be accomplished at night and/or bad weather without disclosing force locations. Cushioning airbags could allow the delivery of even the most fragile items. Current dispensers would require extensive redesign/modification to be used for this mission. The high impact velocity would expose friendly personnel to a high risk of injury as well as destroying the needed supplies. Use of current dispensers for these type missions is currently precluded by hazardous impact of the delivery vehicle in occupied areas and the destructive impact velocities.

Phase I: Evaluate latest technologies in lightweight, low-volume retarding and cushioning devices. Develop retardation and cushioning hardware for a Soft Landing aircraft delivered dispenser. Conduct design trade studies to evaluate concepts against the desired delivery performance in operational environments of weather, wind, and terrain. Accomplish the preliminary design of the best concept and develop the system requirements.

Phase II: Accomplish the detail design of the retardation and cushioning hardware and build a prototype. Demonstrate the merit of the prototype design through a combination of detailed analysis, digital simulation, hardware-in-the-loop testing, laboratory tests replicating operational conditions, and/or testing in actual operating conditions.

Dual Use Commercialization Potential: The hardware developed in this SBIR will be useful in providing humanitarian supplies to isolated victims of floods and other natural disasters. This supply could be provided with precision and with minimal risk of injuring people on the ground.

Related References:

1. ADA324641 Predictive Model of a Parachute Retraction Soft Landing System
2. ADD426240 Design Considerations for Soft Landing of Balloon Payloads

KEYWORDS: Wind Corrected Munitions Dispenser (WCMD), resupply, humanitarian relief, Soft Landing, Air Delivery, precision delivery

AF03-157 TITLE: Enhanced Circuit Protection and Safety via Arc Fault Circuit Interrupters for Military/Commercial Aircraft

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: To develop and fabricate arc fault circuit interrupters (AFCI) that provide arcing fault protection, in addition to traditional circuit protection, through the use of an electronic circuit combined with a conventional bimetal-based circuit breaker.

Description: An arc fault can occur when the insulation between electrical conductors at different potentials fails and the conductors touch each other or are within breakdown conditions. By the time a fuse or circuit breaker opens to defuse the condition, a fire may have already begun. Arc fault circuit interrupters use electronics to diagnose when arcing, or jumping, occurs in a wiring system and then act immediately to shut down the circuit. Because most aircraft wiring is hidden from view, remote detection and feedback are considered particularly important safety features. Innovative ideas are sought to develop an AFCI possessing the following characteristics: resistance to EMI/RFI effects, integral electrothermal bimetal-based circuit protection, similar form and levels of reliability as traditional circuit breakers, remote sensing, and feedback and resetting capability.

Phase I: Clearly identify knowledge and understanding of problem or opportunity. Identify promising solutions. Provide a detailed test plan from which contractor will demonstrate feasibility of concept and superior performance as well as the scalability of the concept. Finally, an accurate model of performance is expected.

Phase II: Optimize proposed device in order to begin specific advanced development and qualification testing. AFCI fabrication, test and delivery with prototypical hardware system demonstration expected.

Dual Use Commercialization Potential: Utilities, military and commercial aircraft arc fault detection/circuit interrupters, residential arc fault circuit interrupters for fire prevention.

Related References: F. Cannaro, B. Peterson, C. Cobb "Circuit Protection for Advanced Aircraft—A Functional and Historical Perspective" SAE paper 872502, 1987.

KEYWORDS: Circuit protection technology, wiring arc fault, arc fault detection, arc fault circuit interrupter, wire insulation failure, aging aircraft

AF03-158 TITLE: Oil-free Bearing Technologies for Aerospace Power Systems

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: The objective of this topic is to develop technology for oil-free, non-contact shaft levitation of an integrated power unit using a combined electric machine/bearing and foil bearings as synergistic mechanisms for rotor support.

Description: As stated above, the objective is to develop technology for oil-free, non-contact shaft levitation of an integrated power unit using the synergistic mechanisms mentioned. In this context an integrated power unit is a turbomachine that has an electrical machine (motor/generator) as a shaft-mounted component that rotates at shaft speed; it would supply power for electrically starting an aircraft's main propulsion engine and other utility functions. The combined machine/bearing is an electrical machine that has its magnetic flux actively controlled to not only produce electrical power, but also to produce a radial shaft levitation force. On first inspection, the weak points of one bearing correspond well with the strengths of the other. Investigating this further and developing the innovations necessary to exploit bearingless motor/generators, and thus allow these support mechanisms to share the shaft levitation load, are this topic's focus. Oil-free bearings for rotating machinery offer many operational benefits by eliminating the need for an oil lubrication system and its associated servicing requirements. The two basic options are foil bearings that support the shaft on a cushion of the process gas by hydrodynamic action, and magnetic bearings that support the shaft with an actively controlled field of magnetic flux. Foil bearings are a simple, lightweight solution but are inherently limited in the stiffness, damping, and load capacity they can develop. The literature contains several recent publications on bearingless motors in which the electric machine has been shown to generate a controlled radial force component while generating torque. Note that prior work has developed a hybrid bearing in which the magnetic flux supporting the rotor either shares real estate with the foil bearing or is in very close proximity to it; this approach using a dedicated active magnetic bearing is not of interest under this solicitation.

Phase I: Establish whether developments in bearingless motors can be used to open new applications to foil bearings, with the application of particular interest being aircraft integrated power units. Thoroughly investigate the capabilities of candidate bearingless machines and foil bearings. Examine various approaches to exploiting the complementary performance characteristics of these two components. Verify operation of the preferred approach through analysis and simulation. The overall goal is to determine the feasibility of this preferred approach.

Phase II: Demonstrate the levitation of a rotor that is representative of the speeds and inertias of an integrated power unit rotor in a laboratory rig using the approach developed under Phase I. A subscale rig would be acceptable, provided a full understanding of all relevant scaling issues is developed during Phase II.

Dual Use Commercialization Potential: Many high-speed rotating machines are in use in industrial applications and power generation. These applications would all experience reduced operating costs if a reliable, capable, and affordable oil-free and non-contact bearing option was available.

Related References:

1. C. DellaCorte and M. Valco; "Load Capacity Estimation of Foil Air Journal Bearings for Oil-Free Turbomachinery Applications," NASA TM-2000-209782 or duplicate report ARL-TR-2334; 2000.

2. D. Elrod, R. Hibbs, and J. Scharrer; "Advanced Analysis of Bending Foil Bearings for Cryogenic Applications," AIAA 97-3100, presented at 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, 1997.

3. M. Takemoto, H. Suzuki, A. Chiba, T. Fukao, and M. Rahman; "Improved Analysis of a Bearingless Switched Reluctance Machine," IEEE Transactions on Industry Applications; Vol. 37 No. 1, Jan/Feb 2001.

4. A. Chiba, M. Hanazawa, T. Fukao, M. Rahman; "Effects of Magnetic Saturation on Radial Force of Bearingless Synchronous Reluctance Motors," IEEE Transactions on Industry Applications; Vol. 32 No. 2, Mar/Apr 1996.

5. T. J. E. Miller; "Faults and Unbalance Forces in the Switched Reluctance Machine," IEEE Transactions on Industry Applications; Vol. 31 No. 2, Mar/Apr 1995.

KEYWORDS: rotor dynamics, bearing, magnetic bearing, foil bearing

AF03-160 TITLE: Health Monitoring for the Integrity of Electrical Power Wiring and Power System Components

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: Develop techniques that enable the evaluation of aerospace electrical power system insulation integrity for wiring, interconnections, and passive or rotating loads, especially in subatmospheric environments.

Description: This topic solicits advanced and innovative concepts related to establishing the integrity of electrical insulation in power system components and subassemblies, under operational conditions, for the purpose of predicting incipient failures. In commercial and defense power electronics, high frequency power conversion is playing an increasingly more important role. This is evidenced in various applications, including power supplies with high intermediate frequency switching, radar modulators, and solid-state lighting ballasts. At higher frequencies, the breakdown field stresses (which determine partial discharge inception voltage) are typically derated from those at low frequencies (less than 400 Hz). High voltage electronics in aerospace equipment may have to operate for long periods at subatmospheric pressures or in gaseous environments with low ionization thresholds. Irrespective of the operating frequencies, this environment will also lower the partial discharge inception levels. Most conventional discharge detection systems are designed for operation at low frequencies and in atmospheric air. Specialized detection techniques are necessary to fulfill corona and partial discharge detection requirements for high power, aerospace equipment (i.e., dedicated weapons system power). Sensors and detection systems must be capable of operation in low-pressure air, non-atmospheric gases and at high power frequencies. Detection systems that can operate with higher excitation frequencies or non-atmospheric gases also have potential application to low voltage insulation evaluation under controlled test conditions and environments. The lowering of partial discharge inception thresholds by frequency or gaseous medium may allow for lower applied test voltages in low voltage wiring integrity testing. In any case, the detection system must be capable of calibration via a standard technique, for potential incorporation into international test standards, for offline qualification testing. This is necessary for certain high power electronic devices (with integral high field stresses) that must operate with high reliability and predictable lifetimes. Since the detection methodologies are to address concerns in electrical insulation systems, it is logical that techniques might be electrically based, i.e., conducted or radiated signals: however, thermal, acoustic, optical, and gaseous techniques should not be overlooked. Diagnostics may be tailored to specific, high cost system components to extend useful operational life via predictable, incipient failure indicators. Sensors may need to be made a part of the device, without disturbing the electrical or mechanical characteristics. Finally, the research should focus on providing techniques to detect discharges or incipient failures to establish the integrity of electrical insulation in power system components and subassemblies (operating at high frequencies, in low pressure air, or non-atmospheric gases) for flight vehicles in which weight, volume, packaging, and environmental constraints are major factors.

Phase I: Develop a detailed technical definition of the problem, identify a proposed solution, and demonstrate the key technologies enabling the use of that solution. This phase should focus on the demonstration of specific techniques that could be implemented in offline evaluation and qualification procedures, while meeting the environmental (down to 0.001 torr) and operational (up to 1 MHz) constraints.

Phase II: Concentrate on development of prototype components, subsystem demonstrations, and hardware and software development.

Dual Use Commercialization Potential: All of the technologies developed under this topic can be transitioned to commercial air vehicles and similar systems for ground vehicles and ships, as well as ground facilities. Specific technologies may be incorporated into onboard, online diagnostic systems.

Related References:
1. Proceedings, Electrical Insulation Conference and Electrical Manufacturing and Coil Winding Conference, Cincinnati, OH, October 1999.

2. Proceedings, 23rd International Power Modulator Symposium, Rancho Mirage, CA, June 1998.

3. Proceedings, IEEE International Symposium on Electrical Insulation, Anaheim, CA, April 2000.

4. W. Pfeiffer, "High Frequency Voltage Stress of Insulation," IEEE Transaction on Electrical Insulation, Vol. 26, No.2, April 1991.

KEYWORDS: Electrical Power Systems, Insulation, Integrity, Reliability, Diagnostics, Interconnections

AF03-161 TITLE: Technologies for Elimination of Hyrdazine in Aerospace Power

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: The objective is to develop environmentally friendly monopropellant technologies for compact aircraft power systems.

Description: There are approximately 3000 aircraft currently in use around the world. The emergency power unit (EPU) for this single-engine fighter uses hydrazine as its fuel. Hydrazine is a known mutagen and may soon be placed on the list of known carcinogens. Special facilities for refilling the hydrazine tanks after use are provided at every base where aircraft are stationed or serviced. Air Force personnel must wear protective gear and special training must be provided for normal aircraft servicing and for cleanup after EPU usage or hydrazine spills. Recently, the Occupational Safety and Health Administration (OSHA) reduced the allowable exposure levels for hydrazine from 1 to 0.1 parts per million (ppm). The American Conference of Governmental Hygienists recommends reducing exposure to 0.01 ppm. There even exists the possibility of a total ban on hydrazine usage. Another concern is that equipment currently in use is only sensitive enough to detect levels down to 0.05 ppm. All these machines will have to be replaced if the lower limit is established. Because of these concerns, the Air Logistic

Commands (ALCs) have implemented a plan aimed at reducing hydrazine usage. Nontoxic replacement systems would remove the threat of accidental hydrazine exposure and meet the ALCs goals by totally eliminating hydrazine from the flight line. Other systems such as jet propulsion (JP) Fuel/Oxygen combustion have been evaluated, but due to their lower energy density these systems are either much too large to fit into the available space or do not provide the performance requirements of the aircraft EPU. Alternate, comparable monopropellant systems are desired which offer similar performance without toxicity. Work is needed in the definition of the fuel, catalyst, and other system components.

Phase I: Contractor should be able to show predicted system performance (energy per unit mass, ignition temperature, freezing point, storage life, etc.) comparable to or better than existing aircraft EPU. Effort should also show proof of the system's environmental friendliness.

Phase II: This effort should result in a full-scale working model of the proposed system. The exact flight configuration is not necessary, but the system should prove out fluid feeds, flow kinematics, power production, and combustion stability. The prototype should demonstrate both the hardware and the software that are required for the power system.

Dual Use Commercialization Potential: A replacement system for the aircraft hydrazine based emergency power unit may have application in other aerospace systems now using hydrazine, including the space shuttle.

Related References: Technical need #: 95A0076, "Evaluation and Rejuvenation of Iridium Catalyst"

KEYWORDS: secondary power, monopropellants, hydrazine, environmentally friendly, catalyst, high power density

AF03-162 TITLE: Nonflammable Lithium-ion Battery Electrolytes Capable of Extended Operational Temperature Ranges

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: Develop electrolyte/solvent for safer, more reliable Lithium-ion batteries, which will be nonflammable during fabrication or in the completed battery, which may or may not utilize alternative ionic solutes, which are capable of sustained operation at high temperatures and whose overall operational temperature range should approach –40C to +80C.

Description: This topic seeks proposals with innovative concepts related to Li-ion battery electrolytes. One of the biggest problems with the current organic electrolyte solvents is their extreme flammability. These flammable materials are used because they form very conductive solutions with lithium salts. Furthermore, it has been shown that a beneficial passivating film forms on the anode in the presence of these materials. However, the flammability represents a safety problem at the manufacturing site and could possibly be a safety problem should the integrity of a sealed battery be breached. This topic seeks new electrolytes or solvent/electrolyte combinations that can withstand operation at high temperatures (ca. 80C) and will demonstrate ionic conductivity equal to or superior to current carbonate- or ether-based electrolytes but not be as volatile or flammable. These new electrolytes, solvents, or solvent/electrolyte combinations should exhibit good conductivity during discharge and charging operations over a large temperature range (-40C to +80C). New electrolyte systems should also exhibit a large electrochemical window and good stability, over a high temperature range, with both the anode and the cathode. They should be both environmentally and biologically friendly.

Phase I: Define the proposed concept, define the basic physics and chemistry of the materials selected, predict the performance of the proposed design, and through analysis and testing, demonstrate melting/freezing points and ionic conductivity over as wide a temperature range as possible. Short term and long-term stability with electrochemically active battery materials and electrochemistry, including electrochemical window should also be determined. Safety and nonflammability should be demonstrated. The potential environmental and biological compatibility of the new materials should be identified.

Phase II: Provide an operable prototype component or system that is completely suitable for the intended application. Address scalability to other sizes, geometries, discharge rates and chemistries to allow for additional applications for evolving Lithium-ion batteries. The prime consideration must be deliverable hardware, a working battery, and a clear demonstration of a manufacturable device, component, or system that improves the existing technology either through exceptionally high performance, significantly reduced cost, or improved safety.

Dual Use Commercialization Potential: Li-ion batteries are the rechargeable battery of the future with tremendous opportunity for application in military as well as civilian environments for items such as small appliances, computers, camcorders, cell phones, cameras, and electric vehicles of all types.

Related References: Sohrab Hossain, "Rechargeable Lithium Batteries (Ambient Temperature)", Handbook of Batteries, 2nd Edition, edited by David Linden, Mc Graw-Hill, 1994, pp. 36.01-36.77.

KEYWORDS: Lithium-ion Batteries, nonflammable, electrolyte, safety, temperature extremes, electrolyte.

AF03-163 TITLE: <u>High Current (40 to 100 amp) Solid-State Power Control (SSPC) Technology</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Electronics

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: Develop high-current (40 to 100 amps), 270 volts of DC solid-state power controllers for power management and fault protection for applications in both commercial and military electrical power systems.

Description: The more-electric aircraft (MEA) concept is recognized as offering significant operational and life cycle cost benefits over the more hybridized secondary power systems that are now in place on fielded aircraft. On an MEA-type aircraft with a 270-volt DC primary electrical power system, electrical loads typically range from 5 to 100 amps. State-of-the-art SSPCs are available up to approximately 25 amps. There are two primary reasons to control loads above 25 amps with SSPCs. First, SSPCs are significantly smaller and lighter than electromechanical power contactors (EMPCs.) Second, the faster switching times possible with SSPCs provide superior fault isolation capability. SSPCs typically have trip response times of between 5 and 15 microseconds versus 15 to 110 milliseconds (depending on the rating) for EMPCs. Innovative ideas are sought to bridge the current carrying gap between SSPCs and EMPCs while maintaining the positive characteristics inherent in state-of-the-art SSPCs.

Phase I: Clearly identify the problem or opportunity to be addressed by the proposed research. Define the conceptual design and predict the performance of the proposed design through analysis, preliminary modeling and simulation. Explore the feasibility of new concepts through analysis and/or small-scale testing. All concepts should be scaleable or flexible designs that can support various mission applications.

Phase II: Provide detailed design and prototypical device or hardware demonstrations. Models and/or simulations, validated by demonstrations and which fully capture the relevant physics, are typically expected. A clear definition of failure modes would be expected as well as the ability to meet required operational lifetimes.

Dual Use Commercialization Potential: This technology may have application in future commercial aircraft.

Related References:
1. Air Force Research Laboratory, Propulsion Directorate, Power Division web-site: http://www.pr.afrl.af.mil/divisions/prp

2. Product Function Spec MDEPS004.

KEYWORDS: solid state power controller, solid state relay, fault isolation, high current solid state switching, power switches, power conditioning

AF03-164 TITLE: Application of Microsystem Technologies in Advanced Aerospace Vehicle Power Systems

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Airlift & Trainer (AT)

Objective: Demonstrate the potential for the pervasive use of current and evolving Microelectromechanical Systems (MEMS) technologies in aerospace vehicle power systems.

Description: There are many challenges in transitioning Microelectromechanical Systems (MEMS) technologies to specific and diverse applications that will benefit in cost, weight, manufacturing, reliability, etc. MEMS devices to date have had limited evolution from the novel microdevices to specific applications such as microsensors. For the most part, the development of microsensors, such as accelerometers, pressure sensors, have been the primary focus for transitioning this microtechnology to real world applications. Barriers to applying MEMS technologies in specific applications other than microsensors have been: (a) gaining access to fabrication facilities and (b) combining the diverse technical expertise required to leverage MEMS technologies to a variety of applications. It is desirable to demonstrate the pervasive use of innovative microsystems integral to aerospace vehicle prime power and secondary power systems that will result in system level benefits. These innovative microsystems may incorporate, but not be limited to, such approaches as microsensing for diagnostic surveillance, microfluidics for thermal control, or microscale control of macroscale processes. Microsystems integral to aerospace power systems will ultimately be required to operate in environments typifying prime power and secondary power systems for current and future aerospace vehicles.

Phase I: Goals for Phase I should include a feasibility demonstration, either analytical or experimental, of the proposed microsystem concept, address integration issues, and provide sufficient analysis to demonstrate prime power system or secondary power system level payoffs. Definition of the total microsystem including functions, operations, energizing or powering, and fault tolerance should also be addressed.

Phase II: Goals for Phase II should include sufficient demonstration of the proposed microsystem concept to show integration viability into an aerospace vehicle prime power system or secondary power system.

Dual Use Commercialization Potential: The development, demonstration, and integration of robust microsystems into aerospace vehicles represents numerous technical challenges requiring innovative solutions which, in turn, can be directly applied in the military and private sectors. Examples of potential military and commercial applications may include, but not be limited to, integral cooling of power conditioning electronics, diagnostic and control of combustion processes, and health monitoring of power generation system components.

Related References: Ameel, T.A., Warrington, R.O., Wegeng, R.S., and Drost, M.K., 1997, "Miniaturization Technologies Applied to Energy Systems," Energy Convers. Mgmt., Vol. 38, No. 10-13, pp. 969-982.

KEYWORDS: MEMS, microfluidics, power generation, flight control, actuation, power electronics, motor control, electric motors, thermal management

AF03-166 TITLE: Engine Acoustic/Screech Sensor

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop High Temperature Acoustic/Screech Sensor for Engine Nozzle Application

Description: A robust, high temperature, and long life acoustic/screech sensor is desired for a turbine engine application. The technology for sensing high frequency and small displacement, also characteristic of accelerometers, is widely available and has significantly improved in recent years. However, the temperature capability and life are limited to benign applications with ambient temperatures generally below 450 degrees F° (below 350 F°. for flight qualified). or instrumentation applications where life is not critical. The response of instrumentation sensors is in excess of 10Khz. Several technologies including, capacitive, piezoelectric, and piezoresistive, are currently used in fabrication of these sensors, with piezoelectric devices as the most common. State-of-the-art sensor research is taking advantage of silicon micromachining techniques to fabricate smaller, more accurate, devices with on-board data processing. This technology is also known as Micro Electro Mechanical Systems (MEMS). Development of a high temperature acoustic/screech sensor is desired that can operate in the turbine engine augmentor liner environment (550° F) uncooled with a life of 2,000 hours and frequency response of 3,000Hz. The sensor should be small and provide a digital output. Housing development, mechanical linkage, connections, electronics integration, and materials technology should be addressed, as they are critical to achieving a robust long life sensor in the engine environment.

Phase I: The goal of the Phase I program is to evaluate the suitability of electrical, material, and packaging technologies for the high temperature/vibration engine environment and develop a conceptual design for an acoustic/screech sensor.

Phase II: The goal of the Phase II Program is to design, fabricate, and test a sensor based on the technique developed in the Phase I Program. Suitability of the sensor for the turbine engine vibration/damage measurement application will be demonstrated.

Dual Use Commercialization Potential: Commercial Aircraft, Ground Based Turbines, Commercial Instrumentation and Test Applications.

Related References: AIAA Paper 2001-3766, 37th Joint Propulsion Conference, Salt Lake CIty, Utah, July 8th 2001 "Turbine Engine Augmentor Screech and Rumble Sensor"

KEYWORDS: Pressure Sensor, MEMS, High Temperature Sensors

AF03-167 TITLE: T4.1 Gas Path Sensor Technology

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Develop Engine Gas Path Sensor for Above 3200 F Environment

Description: Gas temperature measurement in a turbine engine is a critical parameter for specifying the life and power extraction of the turbine rotor system. It may also be required for future advanced systems employing active combustion control or active pattern factor control. Current methodology uses an estimate of the fuel heat release to estimate combustion gas temperature. Pyrometry, both optical and electrical, has been employed with moderate success to estimate metal (blade) temperatures in the turbine rotor section. These sensors were used for diagnostic and health management functions. Black Body gas temperature sensor technology was demonstrated with capability over 2,500 F. and Laser Induced Fluorescence (LIF) fiber sensors were demonstrated in the laboratory to have capability (uncooled) to 3,000 F. However, several constraints limited the practicality of these technologies for production engines, they include, drift and serious calibration errors, hysteretic errors, limited life, combustion product deposits, and frequency response. Development of a robust gas path sensor that operates uncooled in excess of 3,200 is desired. The sensor should be self calibrating, and not suffer damage from long term exposure to combustion products. The response of the sensor must be above 500HZ.

Phase I: The goal of the Phase I Program is to evaluate both contacting and non-intrusive sensor technologies for high temperature gas temperature measurement capability and develop a conceptual design for a realistic engine sensor. Development of a robust sensor with suitable life, size, and performance characteristics is the focus of this effort.

Phase II: The goal of the Phase II Program is to design, fabricate, and test a sensor based on the technique developed in the Phase I Program. Suitability of the sensor for the turbine engine vibration/damage measurement application will be demonstrated.

Dual Use Commercialization Potential: Commercial Aircraft, Ground Based Turbines.

Related References: "Flight testing of a fiber optic temperature sensor", Specialty fiber optic systems for mobile platforms and plastic optical fibers; Proceedings of the Meeting, Boston, MA, Sept. 9-11, 1992 (A93-49462 21-06)

KEYWORDS: High Temperature Sensor, Gas Path Sensor, non-intrusive sensor, turbine combstor temperature sensing

AF03-168 TITLE: Enhancing Engine Operating Envelope by Ignition and Lean Blowout Modeling and Simulation

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: The overall program objective is to develop physics-based models to predict combustor ignition and lean blowout limits in gas turbine engine combustion systems.

Description: Computational Fluid Dynamics (CFD) is routinely used to the predict steady-state characteristics of gas turbine combustor performance, such as gas temperature and pollutant emissions. This information is critical to improved combustor design. Lacking in these models is the ability to predict transient effects in the combustion chamber that occur during ground ignition, altitude relight, and lean blowout conditions. Current practice is to characterize the engine operability during expensive rig, engine, and flight tests. The ability to predict combustor ignition and lean blowout during the combustor design and development phase will improve engine performance, decrease design cycle time by 25 percent, and reduce costly tests by 30 percent. Innovative ideas are sought to develop modeling and simulation tools to predict combustor igntion and lean blowout. These models would be incorporated in the CFD code for evaluation during preliminary and detailed design phases.

Phase I: Phase I objectives are to demonstrate the feasibility of developing an ignition and lean blowout submodel for use in CFD codes, and to identify critical combustion system parameters that impact ignition performance.

Phase II: Phase II objectives are to develop an ignition and lean blowout submodel for use in CFD codes, and validate these models with existing combustor rig and gas turbine engine data.

Dual Use Commercialization Potential: Operability is usually the last performance parameter investigated during a combustor development program, but is the most important combustor attribute in terms of performance and safety. Early assessment of combustor operability can prevent schedule delays, decrease development cycle time, and reduce testing costs. The modeling and simulation proposed can benefit commercial and military gas turbine users, as well as ground-based and auxiliary power units.

Related References:
1. General information on the Propulsion Directorate can be found at: http://www.pr.afrl.af.mil

2. Ballal, D. R., and Lefebvre, A. H., "Ignition and Flame Quenching of Flowing Heterogeneous Fuel-Air Mixtures," Combustion and Flame 35:155-168 (1979).

3. NASA Advanced Subsonic Technology Review, Highlighted as a critical need by industry to develop advanced, lean-direct injection combustion systems.

KEYWORDS: combustors, ignition, blowout, modeling, simulation, transients

AF03-169 TITLE: FMECA / EHM System Design Technology

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Develop Integrated EHM Design Technology Incorporating the FMECA Analysis Process

Description: Failure Modes Effects and Criticality Analysis (FMECA) is a critical design review technique that focuses on processes and prioritized actions to reduce the risk of failures in the field and document the review process. Benefits from this analytic design review process will result in significant cost savings by focusing on potential reliability problems before failures/damage occurs. This contrasts with the Operational Centered Maintenance (OCM) philosophy, which is only reactive, and ultimately, more costly. Data generated from FMECA analysis, in addition to its impact on the design process, is typically used to develop a Reliability Centered Maintenance (RCM) plan and provide information for the Engine Structural Integrity Program (ENSIP). A recent development in modeling and optimization techniques, combined with data from the FMECA process, is a potentially high payoff method for accomplishing EHM system design and tradeoffs. Development of EHM system design technology is desired with applications to current and future aircraft engines. On currently fielded engines, such as the F100, updating the FMECA and performing EHM design for the engine control and diagnostic system upgrade offers significant benefits in maintenance cost reduction. For example, the original F100 FMECA was accomplished prior to qualification of the engine in 1973. Following the first release (dash 100), three major upgrades to the engine were accomplished, ending with the F100-229. The FMECA for the F100 has not had a major update since qualification. Although F100 applicability is desirable, it is not a requirement to achieve the research goals. Development of technology to perform EHM system design for an advanced engine, such as on the JSF aircraft, is desired. The FMECA process employed takes advantage of new automated methods which reduce the labor required, improve the accuracy of the results, and document the reporting in a standardized way. Coordination with the responsible engine company is required to obtain the required data inputs.

Phase I: The goal of the Phase I program is to develop EHM system design tools incorporating the FMECA process to provide a full EHM System design capability. The tools must be applicable to upgrading current turbine engine diagnostic systems, including FMECA analysis, and performing new EHM system designs on advanced engines. Modeling and simulating the operation of the design tools is required.

Phase II: The goal of the Phase II program is to use the tools developed in the Phase I effort to perform a FMECA, upgrade on a current turbine engine, or demonstrate on an advanced engine an EHM system design capability and trade analysis.

Dual Use Commercialization Potential: Commercial Aircraft, Ground Based Turbines.

Related References:

1. "Development of automated computer-aided diagnostic systems using FMECA-based knowledge capture methods", Reliability and Maintainability Symposium, Anaheim, CA, Jan. 19-22, 1998, Proceedings (A98-20442 04-38), Piscataway, NJ, Institute of Electrical and Electronics Engineers, Inc., 1998, p. 285-291

KEYWORDS: Turbine Engine, Failure Modes, Effects Analysis, Engine Health Management, Turbine Engine Modeling, FMECA Modeling

AF03-171 TITLE: Intelligent/Virtual Rotor Bearing System and Design Through Modeling and Simulation

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Develop user friendly, intelligent virtual rotor bearing system design tools that can act as a design expert during development of advanced propulsion systems. Such integrated modeling and simulation techniques will also enhance affordability and durability of lubrication and support technologies.

Description: The objective of advanced propulsion systems pushes rotor bearings to the limit. One aid in ensuring the most rapid and cost effective design process would be rotor bearing system design tools that are user friendly and have some intelligence. Software tools for design and analysis of proposed concepts can significantly reduce these development costs. Determination of structural and thermal loading for mechanical systems as a function of engine operating conditions is critical to the proper design of these components. Modeling and simulation using available/dedicated analysis and integration algorithms can significantly improve current state of the art in this area. It is the goal of this SBIR topic to develop modeling schemes that can be used to evaluate structural and thermal management concepts as they relate to lubrication and rotor support technologies. Such a virtual design tool could assist the machine designer in applying design experience as well as rapidly evaluating many design alternatives such as active balancing. This could be used to develop a capability to simulate rotor support and lubrication mechanisms. This capability could be utilized for independent analysis when given external boundary conditions such as surrounding structure temperature along with lubricant and secondary air pressures and temperatures or could be used as part of a more complete engine cycle analysis for an integrated solution. Such concepts could include magnetic and foil bearings, thermal management concepts such as carbon-carbon bearing cages or heat pipes to link the rotor support with a heat sink. Key features would include a modern graphical interface, ability to incorporate and apply guidelines based on previous experience, and intuitive, efficient graphical post processing capability.

Phase I: Identify the requirements and approach for the advanced design tool and modeling techniques.

Phase II: Implement the approach in an advanced virtual design tool for rotor bearing systems. Focus should be on prototype of integrated model capability for enabling integration with available engine models. Demonstrate on mutually agreed upon engine operating conditions to include structural and thermal analysis of rotor support and balance system.

Dual Use Commercialization Potential: Results of Phase I & II shall be applicable to military and commercial engine and turbomachinery design and modeling and troubleshooting. Ability to accomplish detailed analysis of component issues and evaluate influence at system level is key to military needs and provides industry with a tool to enhance investment strategy.

Related References: General information on the Propulsion Directorate can be found at: http://www.pr.afrl.af.mil
1. Gupta, P., "Advanced Dynamics of Rolling Elements", Springer-Verlag, Berlin, 1984.

2. Brown, J.R., and Forster, N.H., "Operating Temperature in Mist Lubricated Rolling Element Bearing for Gas Turbines," AIAA 2000-3027.

3. Sankar, T.S., "Rotor Dynamics - A-state-of-the-art," Canadian Society for mechanical Engineering, Transactions, volume 5, number 1, 1991, pp. 1-42.

4. Wang, S.S., tsuei, Y.G., Yee, E.K., "A Knowledge Based Substructuring Study for Rotor Dynamics," Porc. IMAC57, volume 1. 1989, pp. 384-389.

5. Rajan, M., Rajan, S.D., Nelson, H.D., Chen, W.J., "Optimal Placement of Critical Speeds in Rotor-Bearing Subsystems," ASME Journal of Vib. Acoust. Stress and Reliability in Design, volume 109, 1987, pp. 152-157.

KEYWORDS: rotor support and lubrication mechanisms, rotor dynamics, rotor bearing dynamics, virtual design systems for rotors and sensors

AF03-172 TITLE: Advanced Separator Materials For Batteries

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop advanced separator materials for space Ni-H2 batteries.

Description: This topic seeks proposals to evaluate advanced separator materials to those used in existing Nickel-Hydrogen (Ni-H2) batteries for space applications. The new materials would have equivalent or better performance than the existing separator materials in air and space applications. In addition, the material should be equal to or minimally more expensive in production costs to the existing material and use environmental materials and processes in the fabrication of the separator material. The sources of advanced separator materials for existing Ni-H2 batteries are going out of business due to environmental control requirements. This will necessitate qualification of existing battery designs using old separators, significantly reducing reliability, temperature performance, and increasing satellite launches using these batteries. Advanced equivalent separator materials would allow qualification by similarity and eliminate/minimize test costs and supply shortages for operational weapon systems.

Phase I: Identify potential separator materials, fabrication processes, and starting materials with emphasis on environmental processes and starting materials in the manufacturing process. Evaluate the material properties of candidate materials through analysis and sub-scale testing to demonstrate equivalent or better performance characteristics compared to existing space cell separator materials. Identify manufacturing cost factors and estimate their magnitude for proposed demonstration candidates for space applications.

Phase II: Select three candidate batteries from space applications and substitute the separator materials in the cell design, and test and demonstrate equivalent performance to existing qualified cells. Identify minimum qualification tests, costs, and schedule needed to fully qualify the new material in production batteries for one or more of the potential applications. Deliver prototype batteries with selected designs for validation and qualification tests.

Dual Use Commercialization Potential: Ni-H2 batteries are used in numerous commercial applications, such as aircraft, electric/hybrid vehicles, communication satellites, and portable electronic devices of all types.

Related References:
1. T. Jamin, N. Tassin, A. Delahaye, P. Vermeiren, J. Bouet, and M. Schautz, Proceedings of the 5th European Space Power Conference, Tarragona, Spain, Sept 21-25, 1998, Vol. 2, p. 689-694, 1998.
2. F. Thominette, I Driouich, J. Verdu, T. Jamin, J. Bouet, and Y. Borthomieu, Proceedings of the 5th European Space Power Conference, Tarragona, Spain, Sept 21-25, 1998, Vol. 2, p. 681-686, 1998.
3. J.A. Cook and I.M. Lancaster, "Selected Battery Topics. Proceedings of the Symposia," Proceedings of the Electrochemical Society, Vol. 98-15, p. 55-61, 1999.
4. J. Bennett and Wai M. Choi, Proceedings of the 13th Annual Battery Conference on Applications and Advances, California State Univ., Long Beach, CA, Jan 13-16, 1998, p. 153-157, 1998.

KEYWORDS: Energy Storage, Batteries, Electrochemical Energy Storage, Seprator Materials, Battery Separator

AF03-173 TITLE: Aero Propulsion and Power Technology

TECHNOLOGY AREAS: Air Platform, Space Platforms

Objective: Develop innovative technologies which provide major improvements in gas turbine engines, advanced propulsion systems, electrical power systems, and advanced fuels for manned and unmanned applications.

Description: The Propulsion Directorate aggressively pursues and solicits innovative ideas offering major performance advances in all areas of airbreathing propulsion including turbine engines, advanced and combined cycle engines, fuels, and electrical power. Payoffs include increased aircraft and weapon system effectiveness, survivability, reliability and affordability. Turbine engine technology development is focused on delivering higher thrust-to-weight ratios, reduced cost, improved efficiency, and increased reliability. Advanced and combined cycle engine efforts are focused on developing innovative and high Mach airbreathing engines for future manned and unmanned applications. Fuel technologies are currently focused on imporving the performance (thermal stability, low temperature properties, etc) of JP-8 through the use of additives. Finally, electrical power efforts (non-propulsive) are focused on advanced techniques for power generation, energy storage, and power management and distribution for aircraft, spacecraft, and weapons with a particular emphasis on directed energy weapons. Subsets of these technologies include innovative combustion measurement techniques, diagnostics, control techniques, microelectromechanical machines (MEMS), and engine related materials technologies. Offerors are strongly encouraged to establish realtionships with suppliers of the aerospace systems relevant to their research in order to facilitate technology trasition. Proposed efforts shall emphasize dual-use technologies that clearly offer commercial as well as military applications. Proposals emphasizing "spin-on" technology transfer from the commerical sector to military applications are also encouraged.

Phase I: Develop the concept and perform analyses and subscale testing to demonstrate the feasibility of the proposed technology. Modeling and simulatiion is encouraged to guide the research.

Phase II: Provide detailed analytical derivations and prototypical device or hardware demonstrations. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

Dual Use Commercialization Potential: New and innovative propulsion and power technology is equally applicable to both military and commercial aircraft engines and power generatiion and distribution systems.

Related References: Air Force Research Laboratory Propulsion Directorate website: http://www.pr.wpafb.af.mil

KEYWORDS: Turbine engines, high speed propulsion, scramjets, fuels, lubrication, electrical power systems

AF03-174 TITLE: Turbine Engine Weight/Maintenance Reduction and Reliability Improvement via Fluidic Controlled Inlet Guide Vanes (IGVs) and Stators

TECHNOLOGY AREAS: Air Platform, Materials/Processes

Objective: Develop a fluidic replacement for electromechanical variable inlet guide vanes (IGVs) or variable stator systems in turbine engines

Description: Current turbine engines require variable IGVs and internal stator vanes to maintain operation during startup and to assure reduced observability of the rotating part. These variable systems are usually actuated through mechanical linkages and hydraulics, resulting in increased engine weight and reduced durability. During engine startup and operation the inlet flow must be vectored by as much as 50 degrees to assure proper operation. Fundamental studies with fluidic control on compressor vanes carried out at the Air Force Research Laboratory, Propulsion Directorate, Turbine Engine Division, Fan and Compressor Branch (AFRL/PRTF) have shown the potential for large levels of flow vectoring through different fluidic approaches. Fluidics would greatly reduce the complexity of variable IGVs and stator systems and result in a significant reduction in engine weight while greatly reducing maintenance requirements. Innovative ideas/solutions to the replacement of mechanically varied IGVs and stators utilizing fluidic flow vectoring are sought. As part of this effort modeling and simulation tools should be developed to reliably design compressor vanes with fluidic control.

Phase I: Demonstrate the feasibility of utilizing fluidic control as a replacement for mechanically actuated IGVs or stators in an engine system.

Phase II: Demonstrate a prototype fluidic-based flow vectoring system as a direct replacement to current compression system component IGVs or variable stators.

Dual Use Commercialization Potential: Military as well as commercial engine systems can benefit from this technology. The reduced maintenance requirements for a nonmechanical flow vectoring system will result in significant cost savings. In addition weight reductions can result in fuel savings that would be beneficial in both commercial and military applications.

Related References:

1. Copenhaver, William, "Turbomachinery Fluid Mechanics: Flow Control Research for Compressible Environments," Proceedings of Air Force Office of Scientific Research Contractors Meeting on Turbulence and Rotating Flows, Aug 14, 2001.

2. Schler, B.J. et al., "Design, Analysis, Fabrication and Test of an Aspirated Fan Stage," ASME paper 2000-GT-618.

3. General information on the Propulsion Directorate can be found at: http://www.pr.afrl.af.mil

KEYWORDS: Turbine-Engines, Compressors, Fluidics, Vectoring, Guide vanes, Stators.

AF03-175 TITLE: Spray Cooling in Micro-gravity Applications

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

Objective: The objective of this program is to develop innovative new spray cooling concepts including modeling and exploratory space-borne experimental techniques. A clear understanding of two-phase flow regimes in the micro-gravity space environment required for building efficient thermal management systems of future space missions is sought.

Description: Future space systems such as space-based laser (SBL) and space-based radar (SBR) require thermal management components which boil and condense heat transfer fluids. These phase change processes are very efficient and offer an order of magnitude mass and volume savings compared to single phase cooling systems. Two-phase fluid flow and heat transfer processes are well understood in terrestrial applications and used to some extent in space vehicles, but a comprehensive understanding of two phase flow regimes in micro-gravity is still lacking and the validity of available theory is debatable. In order to efficiently design future space thermal systems, a clear understanding of the fundamentals of this subject is required. Innovative concepts including modeling and exploratory space-borne experimental techniques are needed.

Phase I: This feasibility phase of the project will demonstrate key elements of the proposed innovations and establish a preliminary design and analysis for integrating the thermal management with the source.

Phase II: This phase of the program will include the detailed design, fabrication and testing of proof-of-principle hardware. In addition to ground testing, a space flight experiment shall be planned.

Dual Use Commercialization Potential: Many terrestrial applications of the spray cooling systems exist in HVAC industries, power generation plants and aerospace electronics. This SBIR effort would contribute to a better understanding of the science issues of both earth gravity and microgravity conditions on a comparative basis. Military applications include various satellites and space platforms.

Related References:

1. K. S. Rezkallah,"Recent Progress in the Studies of Two-phase flow at Microgravity Conditions," Adv. Space Research Vol 16 No 7 pp (7)123-(7)132, 1995 COSPAR.

2. D. P. Shatto and G. P. Peterson,"Pool Boiling Critical Heat Flux in Reduced Gravity," J of Heat Transfer 1999. ASME Nov 1999, Vol 121 pp865-873.

3. L. C. Chow, M. S. Shambey and M. R. Pai,"High Heat Flux Spray Cooling," Annual Review of Heat Transfer - Chapter six, Vol 8, Ed C. L. Tien, Begell House, New York, 1997.

4. General information on the Propulsion Directorate can be found at: http://www.pr.afrl.af.mil

KEYWORDS: Thermal management, Two-phase flow, Spray cooling, Heat transfer, Microgravity, Space flight experiment

AF03-176 TITLE: Supersonic Combustion Transient Analysis and Control

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

Objective: Develop time-accurate prediction tools and control techniques to anticipate unsteady flow processes, and to manage internal flow transients in high-speed engines.

Description: Transient phenomena occurring in quasi-steady flow propulsion systems are inadequately modeled for system design purposes. These phenomena include inlet starting, combustor ignition, and acceleration. This effort would develop flexible, time-accurate, engine system design tools for the design of stable, fully optimized, high-speed propulsion systems. Validate such analysis by demonstrating position control over the internal shock system of a hypersonic, air-breathing engine flow-path. Such control will enable an engine to generate maximum thrust while maintaining an adequate stability margin.

Phase I: Develop a computational framework for transient analysis of high-speed propulsion system, especially a scramjet. Identify control strategies consistent with this framework.

Phase II: Validate the analytical tools and control methods by rigorous comparison to experiments in which an unsteady, high-speed internal flow is simulated and imposed transients are identified and suppressed in a time-frame consistent with engine control requirements.

Dual Use Commercialization Potential: Effective transient analysis is a pervasive need, with the potential to impact many types of power plants: furnaces to automobile engines.

Related References:
1. Tokarcik-Polsky, S.and Cambier J., Numerical Study of the Transient Flow in the Driven Tube and the Nozzle Section of a Shock Tunnel, AIAA 93-2018

2. Kailasanath, K., Patnaik, G., Li,C., Computational Studies of Pulse Detonation Engines: A Status Report, AIAA 99-2634

KEYWORDS: scramjet, dynamic control, engine transients, stability margin

AF03-177 TITLE: Package and Personnel Inspection Systems for Installation and Aviation Security

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

Objective: To develop next-generation inspection systems to enhance installation and aviation security through detection and identification of concealed threats in packages and on personnel.

Description: Package and personnel inspection systems currently employed for installation and aviation security applications (e.g., x-ray and magnetic systems) provide useful capability for dense materials but limited capability for detecting and identifying many potentially dangerous materials, including ceramic, plastic, or composite knives and guns; explosives; chemical, biological, and nuclear materials; and gas canisters. Enhanced methods of inspection are urgently needed. Several candidate technologies show great promise for meeting these inspection needs, including time-modulated ultra-wideband radar (TM-UWB) and terahertz (“T-ray”) imaging.

New low-power TM-UWB systems have emerged over the past decade with tremendous potential for radical advances over existing automated inspection systems. Utilization of ultra-wideband signals addresses the most significant problems of radar target observation, namely, the determination of coordinates and their derivatives, discrimination and radar imaging, and the measurement of radar target characteristics. TM-UWB systems generally deliver more information than their conventional counterparts and make it possible to relate scattered radar signals and their components to target geometry. Inherent advantages over mono-pulse schemes include: 1) immunity to continuous wave (CW) interference, 2) sophisticated multi-axis inspection achieved using multiple co-located UWB's, 3) randomized, spread-spectrum emissions that make UWB sensors difficult to detect (stealth surveillance); 4) ultra-wide bandwidth signals arising from ultra-short duration pulses; and 5) extremely low power spectral densities.

Accelerating the development and application of this technology for security-related inspections requires several important advances. The current resolution capabilities of UWB's must be extended to sub-millimeter wavelengths. Detection technology must be enhanced to address a broad dielectric range that includes ceramics and organic-composite materials. These and other advances will enable the development of radiation-hardened TM-UWB technologies for use in hybridized UWB/X-ray inspection systems providing enhanced compositional analysis and automated identification of dangerous materials.

Imaging of terahertz radiation or "T-rays" represents another emerging technology with significant potential for advanced, security-related inspection systems. T-rays are transmitted by many visually opaque objects and materials but reflected by others, permitting complementary imaging in transmissive and reflective modes. Many potentially harmful gases and other chemicals exhibit distinctive spectral fingerprints in the terahertz region. Together these characteristics permit T-ray-based discrimination between harmful and innocuous objects, materials, and chemicals concealed in packages and on personnel through the use of safe, low-power, non-ionizing radiation with no real or perceived health risks.

Time-domain and/or frequency-domain techniques for generating T-rays and detecting transmitted, reflected, and absorbed terahertz radiation must be explored to realize the inspection potential of this technology. Optimized generation and detection schemes must be coupled with imaging approaches based on raster-scanning or "time-reversal" algorithms to move from simple detection to target identification and location determination. Detailed spectroscopic studies of potentially harmful materials are essential for assessing the potential utility of T-rays for inspection applications.

Phase I: The goal of the Phase-I program is to demonstrate the potential for detecting and identifying concealed threats in packages and on personnel using TM-UWB systems, T-ray imaging, or some other suitable technology. This demonstration must be achieved on a laboratory scale. Computer simulations and paper studies represent a necessary but not sufficient element of this demonstration. Phase-I activity should also include preliminary trade/marketing analysis and initiation of a commercialization strategy.

Phase II: The goal of the Phase-II program is to develop and deliver a prototype inspection system capitalizing on the successful Phase-I demonstration. The trade/marketing analysis and commercialization strategy initiated in Phase I should be further developed. Life-cycle costs for production, operation, and maintenance of widely fielded systems (e.g., full-body portals for screening of personnel, luggage/package scanning systems, portable devices for installation inspection, etc.) should be addressed in this phase.

Dual Use Commercialization Potential: Security-related dual-use applications abound across the public and private sectors. Package inspection for myriad industrial applications (nondestructive evaluation, part-count determination, etc.) represents another area for successful commercialization.

Related References:
1. L. Yu Astanin and A. A. Kostylev, Ultra-Wideband Radar Measurements: Analysis and Processing (Radar, Sonar, Navigation & Avionics Series), IEE, London, UK, 1997.

2. J. D. Taylor, (Ed.), Introduction to Ultra-Wideband Radar Systems, CRC Press, Boca Raton, FL, 1995.

3. An extensive list of terahertz-radiation links can be found at http://www-ce.rice.edu/~daniel/groups.html.

KEYWORDS: Inspection, Security, Time-Modulated Ultra-Wideband Radar, Terahertz Radiation, T-Rays

AF03-178 TITLE: Oil Free Rotor Support for Small Turbine Engines

TECHNOLOGY AREAS: Air Platform, Materials/Processes

Objective: Develop and demonstrate high-speed, oil free rotor support system for small turbine engines.

Description: Advanced high speed gas turbine engines continually subject the bearings to extreme environments making bearings the life limiting component in the engine. Demonstration of a small to medium-sized core rotor completely devoid of oil will improve weapon system range, reduce weight and costs, and increase overall system reliability. Additional benefits are the potential to eliminate bearing corrosion, improve engine storability, and use an integral starter generator with the oil free shaft system. The challenges to achieving the oil free engine reside in the integration of the radial and thrust bearings with the rotor and starter generator system. Improvements in radial and thrust load capacity for oil-less bearings are needed make the oil free engine a reality.

Phase I: Develop or identify an innovative oil-less bearing and/or rotor-bearing configuration that includes increased radial and thrust load capacity. Show feasibility for an improvement in current oil free bearing technology to allow radial load capacity of over 130 pounds per square inch (psi), thrust load capacity of up to 5,000 pounds, with the capability to fully support a 75 pound rotor through 500 start-and-stop cycles.

Phase II: Fabricate and demonstrate the concept configuration(s) at speeds, temperatures and loads expected in advanced oil free turbine engines of up to 15,000 pound thrust class, with use of appropriate bearing rig and engine test facilities.

Dual Use Commercialization Potential: Commercial Gas Turbines, Microturbines, High Speed Compressors, Limited Life Turbines, UAVs and UCAVs

Related References: none

KEYWORDS: Gas Turbine Engine, Bearing, Oil Free Bearing, Oil-less Radial Bearing, Oil-less Thrust Bearing, Lubrication

AF03-182 TITLE: Deployable, Membrane Optical or RF Reflector,

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop deployable, lightweight, structurally efficient support structures for thin membrane optical or RF reflectors.

Description: The need for solar thermal propulsion optical reflectors, large lightweight RF /optical communications reflectors and large space-based observation platforms has motivated increased research in the development of lightweight membrane optical surfaces. These systems provide the smooth surfaces required for undistorted reflection of RF and infrared to visible-spectrum spatial wavelengths. However, the same thinness that makes these surfaces so lightweight also makes them susceptible to bending, causing inaccuracies in the reflecting surface. The fundamental issue is that a very thin material has little bending stiffness and, thus, responds to on-orbit disturbances as small as gravitational perturbations. Traditional means of adding structural thickness and, thus, bending stiffness are inefficient and massive, defeating the initial objective of developing lightweight, thin reflecting surfaces. Truss structures are the most efficient means of providing reflecting membrane structural support, but their configuration is such that they provide inadequate continuous support necessary to assure undistorted reflections. In addition, truss structures impart undesirable point load distortions on the reflecting surface. Isogrid structures would provide efficient structural bending support without imparting point load distortion; however, any continuous structure, such as an isogrid, used to support the reflecting surface on orbit would also have to support it through spacecraft integration and launch loads. In addition, the structure would have to be thermally stable so as not to impart unwanted loads and distortions on orbit. Inclusion of active shape control elements would also be beneficial. The objective of this solicitation is to develop an innovative solution to the problem of supporting large (20 meter diameter) lightweight (0.5 kilogram/square meter) continuously undistorted (10 nanometers smooth) membrane, space-based optical or RF reflectors.

Phase I: Develop and evaluate innovative support structure concepts that offer superior stiffness, light weight and stability for thin-film reflecting surfaces. Phase I concepts should address basic support structure performance/distortion issues, in concert with the reflecting membrane to support structure integration. Overall analysis and concept level demonstration(s) should provide proof of feasibility for development of a successful thin-film space-based reflector capable of optical level dimensional stability.

Phase II: Phase II shall produce a lightweight support structure integrated with a thin-film reflector. The contractor shall demonstrate the resultant reflector surface/structural performance through mutually (contractor/Air Force) agreed testing and evaluation.

Dual Use Commercialization Potential: Large, lightweight, reflectors will have significant military and commercial applications. These include: RF and optical communications, solar thermal propulsion, surveillance target designation, imaging through clouds, space-based laser satellite characterization system, remote sensing, wind profiling, target illumination, nighttime imaging, assessing soil conditions and vegetation types, camouflage detection, detection of cruise missiles, ballistic missile defense, ground-based laser relay mirror and space-based counterforce.

Related References:
1. J. R. Rotge, D. K. Marker, R. A. Carreras, J. M. Wilkes, and D. C. Duneman, "Large optically flat membrane mirrors," Proc. SPIE – Int. Soc. Opt. Eng. 1999, vol. 3760 p. 207-212.

2. Hinkle, J., Warren, P., Peterson, L., "Structural Performance of a Gossamer Isogrid Column with Initial Geometric Imperfections," Proceedings of the 42nd AIAA/ASME/ASCE/ASC Structures, Structural Dynamics, and Materials Conference and Exhibit, Seattle WA, April 2001

KEYWORDS: Membrane RF Reflectors, Truss Structures, Membrane Optics, Isogrid Structures, Undistorted Reflection, Active Shape Control

AF03-183 TITLE: Improved Specific Strength Materials for Rocket Motor Case Weight Reduction

TECHNOLOGY AREAS: Materials/Processes, Weapons

Objective: Develop a material with significantly improved specific strength over carbon/epoxy composite for use in solid rocket motor cases.

Description: A major goal of the Air Force's Propulsion Technology thrust is to decrease the inert weight of solid rocket motor systems, thereby increasing range and/or payload of the system. This is particularly important concerning the motor case, which must also be strong enough to contain the substantial pressures (on the order of 1000 psi) that occur during motor operation. The major objective is to significantly decrease the weight in comparison to industry standard carbon/epoxy cases. While some progress towards this goal can be achieved through improved case design and manufacturing, it is apparent that new, innovative materials will be required as well. These new materials will require a significantly improved specific strength (ra-tio of strength to weight), either through increased strength, decreased weight, or a combination of the two to achieve the goal. Possible materials include, but are not limited to, improved composites, metal foams, biomaterials, nanomaterials, buckytubes, and the like.

Phase I: Develop and manufacture one or more advanced high strength-low weight materials. Build test samples and case sections and demonstrate the increased capabilities through laboratory mechanical testing.

Phase II: Design a subscale rocket motor case and manufacture it using the new material(s). Demonstrate a decrease in case weight of approximately 30% over the baseline material. Test the material(s) in the case configuration through hydroburst and other standard qualification tests. Manufacture and fire one or more instrumented subscale motors using the new material to demonstrate the capabilities of the material.

Dual Use Commercialization Potential: Materials with improved specific strength would have a dramatic effect on many applications, particularly those where both weight and strength are driving concerns. Examples of these include the commercial and military rocket industry, commercial and military aircraft and rotorcraft, and the automotive industry. In addition, structural applications such as bridges, buildings, and the like would also benefit from these improved materials.

Related References:
1. Sutton, G. P., Rocket Propulsion Elements, 6th Ed., John Wiley & Sons, Inc., 1992.

2. Degischer, H. P., "Innovative light metals: metal matrix composites and foamed aluminum" Materials and Design, Volume: 18, Issue: 4-6, December 1, 1997, pp. 221-226.

3. Gu, Q.; Kettunen, P., "Carbon-carbon composite, Materials Science and Engineering: A, Volume", pp 234-236, August 30, 1997, pp. 223-225.

4. Bleay, S.M.; Humberstone, L., "Mechanical and electrical assessment of hybrid composites contain-ing hollow glass reinforcement", Composites Science and Technology, Volume: 59, Issue: 9, July, 1999, pp. 1321-1329.

5. General information on the Propulsion Directorate can be found at: http://www.pr.afrl.af.mil

KEYWORDS: Solid rocket motor case, specific strength, tensile strength, inert weight, mass fraction composite materials

AF03-185 TITLE: Compact High Current Beam Generator

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space and Missile Systems Center (SMC)

Objective: Develop approach(es) and demonstrate compact/ lightweight technology to create high current beam

Description: A high performance rocket motor for space propulsion and eventually boosters is one of the most important developments required to meet future military space needs. Two of the most critical technologies needed are compact space high power and the ability to accelerate the propellant up to 10^6 m/sec which is equivalent to about 50/100 kev for argon/ water propellants. This topic focuses on the accelerator technology for future rocket propulsion to develop approach(s) and basic technology for a compact/ low mass generator to create a high current beam. To be practical in space the system must be low mass, compact, and efficient; and avoid the problems that inherently come in space with excessive waste heat and high voltages. It appears one of the best approaches may use nanotechnologies to build the equivalent of an accelerator or electric rocket motor on a chip. The modules would be built with the idea that they would be combined on a space vehicle for watts to megawatts of output depending on the application. To be useful for propulsion each module should eventually handle at least 10 kw output, although for this topic a low power version that demonstrates the principles and scalability would be sufficient. While the high power implies eventually using superconductors, other methods such as microchannel cooling may be adequate. While the emphasis in this topic will be on space-based propulsion, the technology could be adapted for other military purposes such as weapons or to enable other launch devices. The resulting technology will be analogous to the laser in some aspects, except this is for matter particles instead of photons.

Phase I: Assess and document existing requirements and revise them as required. Define physical constraints and determine a range of possible approaches through software/ hardware simulations that meet the requirements. Design and integration of lightweight power conditioning will be considered. Make recommendations for the Phase II effort. In addition to nanotechnologies, macroscopic approaches can also be considered. Demonstrate some basic approaches, if possible. Define Phase II plan.

Phase II: Design approach (es) recommended in Phase I, fabricate prototype(s), and demonstrate the basic technology to assess its performance against requirements. Identify approach(es)' shortfalls and make recommendations for future technology development improvements.

Dual Use Commercialization Potential: Possible acquisition programs enabled by this technology include the concepts identified in the references. One potential commercial use would be for cutting or removing any type of material similar to present lasers but possibly with wider applications.

Related References:

1. "High Current Molecular/ Atomic/ Particle Beam," "Miniature Electric Rocket Engine," Launch Operations Volume, 2001 Mission Development Plan, SMC/XR, Oct 2001

2. "High Performance Space Rocket," "High performance Booster," " Space Tug," " Matter Beam," "Beam Mass Transport Device," Launch Operations and Force Application Volumes, 2001 Mission Development Plan, SMC/XR, Oct 2001

KEYWORDS: Beam generator, Accelerator, Nanotechnologies, Electric motor, Superconductor, Microchannel

AF03-186 TITLE: <u>Miniature Satellites Launcher</u>

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space (SP)

OBJECTIVE: Develop Infra-Structure for Miniature Satellite Flight Operations

DESCRIPTION: Technological advances in miniature satellites will usher in a new paradigm for space operations in the future. Currently, the government and university-sponsored projects plan to use Miniature satellites as space test platforms for microelectromechanical systems (MEMS), microdevices, and to evaluate and demonstrate subsystems for miniature satellites. There is a need to create a congruent infrastructure for launch operations with such miniature satellites that is available for rapid access and flight operations to DoD, NASA, the academic community and commercial use developers. A well-conceived launch infrastructure will support and accelerate progress in this new miniature satellite field. The proposed topic will accomplish multi-purpose objectives by encouraging the increased participation of the academic community, while furthering future DoD space systems, and affording a convenient path for commercial developments and assessments. This topic calls for study of small and low cost launch vehicles that can place miniature satellite payloads affordably into low earth orbit. The study shall include three innovative launch-to-orbit concepts, cannon assisted launch, balloon assisted launch and stratospheric aircraft launch.

PHASE I: Analyze prospects for a truly low cost, small launch vehicle. Contact different government agencies (NASA, AF, Navy, etc.) to determine what options are currently available for launching small low-cost vehicles. Identify ground tracking and operations factors that would keep small vehicle costs high. From this gathered information select appropriate architectures that could enable low-cost small launch vehicles. Identify specific technology needs for miniature spacecraft, such as MEMS technology. As a minimum, conduct a preliminary assessment of low cost options to achieve cannon assisted launch to orbit. Develop a Phase II study plan for launch of miniature satellites to low Earth orbit. The point of this SBIR work is to enable low cost access to space for future high-risk, high-payoff technology demonstrations and experiments that are currently too expensive to perform.

PHASE II: Develop an implementation plan for the selected distributed ground station systems architecture to support multi-user miniature satellite development and operations. Address needed component technology to achieve a producible miniature satellite. Conduct proof of principle testing to verify the approach to the ultra-small space launch vehicle, and define the road map to achieve it.

DUAL USE COMMERCIALIZATION POTENTIAL: In addition to government projects, the number of university-sponsored projects is also increased to engage in building miniature satellites. A miniature satellite launcher technology such as that developed for the DARPA program is expected to have both DoD and commercial space-based applications.

RELATED REFERENCES:

1. S. W. Janson, H. Helvajian, E. Y. Robinson, "The Concept of 'Nanosatellite for Revolutionary Low Cost Space System", The Aerospace Corporation, Proceedings of the 44th IAF Congress, Graz, Austria, Oct 1993.
2. H. Helvajian and E. Y. Robinson, "Micro- and Nanotechnology for Space Systems: An Initial Evaluation", The Aerospace Corporation, 31 March 1993.
3. E. Y. Robinson, "ASIM and Nanosatellite Concepts for Space, Systems, Subsystems, and Architectures", The Aerospace Corporation, 1995.
4. Robinson, E. Y., Helvajian, H., and Janson, S. W., "Small and Smaller: The World of MNT", Aerospace America, pp 26-32, September 1996.
5. Robinson, E. Y., Helvajian, H., and Janson, S. W., "Big Benefits from Tiny Technologies", Aerospace America, pp 38-43, October 1996.

KEYWORDS: Miniature Satellites, MEMS, Cannon launch, Balloon launch

AF03-187 TITLE: Tactical Missile Advanced Steering Technology

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Weapons (WP)

Objective: Demonstrate advanced thrust vectoring technology concepts for tactical missiles that provide increased turning rates and maneuverability.

Description: A highly maneuverable air-to-air missile can increase the ability of the warfighter to defeat enemy aircraft at multiple ranges and at different target angles (e.g., off-boresight shots). Development of advanced thrust vectoring technologies will permit tactical missiles to be more maneuverable and fulfill both a short-range and a medium-range mission while limiting additional inert weight. Proposed designs should be compatible with the current medium-range air-to-air missile designs. The final goal will consist of the integration of the thrust vectoring technology into 7" diameter missile hardware. Thrust vectoring coupled with thrust magnitude control may provide significantly more lethality to conventional tactical propulsion. Modeling and simulation is encouraged to provide design guidance as well as evaluate potential system level payoffs. We seek tactical missile thrust vectoring technology that will increase current air-to-air missile turning rates while minimizing energy losses during turning.

Phase I: Design and develop advanced thrust vectoring technology for integration into 7" diameter missile hardware. Tactical missile simulations will also be used to demonstrate utility and feasibility of the design concept. Required Phase I deliverables will include proof-of-concept hardware and simulation results.

Phase II: Integrate and test the thrust vectoring technology in 7" diameter flight-like tactical motors. The demonstration will consist of static firing of the tactical motor concurrent with the thrust vectoring system. Required Phase II deliverables will include vectoring technology hardware test results demonstrating hardware operation in a 7" tactical motor.

Dual Use Commercialization Potential: The technology developed under this program would have significant uses not only in the tactical environment, but also in the commercial launch vehicle environment.

Related References:

1. Sutton, G. P., Rocket Propulsion Elements, 6th Ed., John Wiley & Sons, Inc., 1992.

2. Jensen, G.E. and Netzer, D. W., Tactical Missile Propulsion, Progress in Astronautics and Aero-nautics, Vol. 170, 1996.

3. Vergez, Paul L., "Tactical Missile Guidance with Passive Seekers Under High Off-Boresight Launch Conditions," Journal of Guidance, Control, and Dynamics, Vol. 21, No. 3, 1998, pp. 465-470.

4. General information on the Propulsion Directorate can be found at: http://www.pr.afrl.af.mil

KEYWORDS: rocket propulsion, tactical missile, steering, off-boresight, dual-range tactical, thrust vectoring

AF03-188 TITLE: Directed Beam Infrared Signature Replication of Fighter Aircraft

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Air Armament Center (AAC)

Objective: Develop innovative technologies, using infrared directed beam techniques to provide a configurable infrared signature to replicate threat aircraft signatures using subscale aerial targets.

Description: Current subscale targets support test and evaluation of weapon systems and fighter aircraft. Current infrared plume pods carried on subscale targets do not meet the requirements for threat realism needed to support infrared weapon system signature test and training missions. It is nearly impossible to produce a radiant intensity distribution that is as large as that of a fighter aircraft on a subscale target using conventional infrared augmentation methods.

Computer controlled directed infrared beam techniques offer the potential to emulate the infrared signature of threat aircraft and provide a dramatic improvement in the threat realistic infrared signatures for subscale aerial targets. Infrared weaponry responds to the infrared band irradiance produced by a target. Irradiance is proportional to target radiant intensity in a certain direction and inversely proportional to the distance from the target. The radiant intensity for a fighter aircraft varies with aspect angle. The angular distribution is different for different aircraft and can vary by two orders of magnitude over the complete sphere. Infrared directed beam techniques with appropriate computer controlled broadband infrared sources have the potential to correct current test and training signature deficiencies and can be easily adaptable to replicate a variety of future threat aircraft signatures.

Phase I: This phase will determine the scientific or technological merit, the feasibility of the proposed concept, and its cost effectiveness. Merit and feasibility must be clearly illustrated during this phase through a combination of analytical, empirical, and experimental evaluations. A technical evaluation of the concept or methodology; a demonstration of proof of principle; or a thorough description of the technical approach, cost effectiveness, alternative approaches, and risk factors may also be appropriate in this phase.

Phase II: As proposed by the contractor, a prototype demonstration of the concept, process or idea will complete Phase II. The prototype demonstration is desired on subscale targets or a scaled representation of the air vehicle. The prototype demonstration should have the characteristics of a considerable technical payoff, an affordable demonstration, flight survivable and a subscale target.

Phase III: If Phases I and II result in the demonstration of an effective approach, then this approach will also be demonstrated on the QF-4 as the culmination of Phase III.

Dual Use Commercialization Potential: During Phase I, the application of the processes, technologies and concepts developed as a part of this development should be considered for use on commercial aircraft including helicopters. Commercial uses can be safe navigation in metropolitan environments including approaches through urban areas for landing and passage through urban areas during take off. The technology also can be commercialized for use in aircraft avoidance systems.

Related References:
1. Wagner, W. and Sloan, W.P. "Fireflies and Other UAV (Unmanned Aerial Vehicles), The Sequel to Teledyne Ryan's Lightning Bug." Arlington: Aerofax, 1992.
2. Holmes, S. L. "Targets Directory." Defense Technical Information Center (DTIC), AD Number ADA199322.
3. Jacob, Jonah, "Expanding Beam Laser Amplifier as a Basic Architecture for Scaling High Power Laser," DTIC Report AD Number ADA344515, 14 November 1989.
4. Thompson, J. R. et al. "Beam Handling and Emittance Control," DTIC Report ADA196789, 15 July 88.
5. Neuenswander, David M. "Joint Laser Interoperability, Tomorrow's Answer to Precision Engagement," DTIC Report ADA3090936, 1 May 2001.

KEYWORDS: Infrared, Laser, Sensor, Signature, Pointing, Tracking, Aircraft, Drone

AF03-189 TITLE: <u>Single Step Ultratight GPS Acquisition to Navigation</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Aeronautical Systems Center (ASC)

Objective: To eliminate the dependency on conventional code and carrier tracking loops as a transition tracking state between direct military signal acquisition and ultratightly coupled global positioning system (GPS) / inertial measurement unit (IMU) navigation to improve antijam performance. This effort will focus on high altitude aircraft.

Description: With the recent development of a new class of navigation algorithms called ultratightly coupled GPS/IMU navigation processing (e.g., direct correlator output processing (DCOP), ultratightly coupled (UTC), deeply coupled, direct measurement processing (DMP)), new levels of antijam performance are possible. Current navigation systems use conventional code and carrier tracking loops in their GPS receiver, which may be either loosely or tightly integrated with an inertial navigation system. Ultratightly coupled navigation systems appear to offer improved antijam performance as well as some other benefits compared to these conventional mechanizations. Currently, ultratightly coupled GPS/IMU systems must use a two-step process to achieve steady-state navigation. First, they go through an acquisition process, which must be a direct military signal acquisition for high antijam performance. Following signal acquisition, conventional tracking loops are used to pull in the signals to achieve steady state code and carrier tracking. At this point, the state of the code and carrier-tracking loops can be used to initiate ultratightly coupled processing. Current direct acquisition technology and ultratight systems can operate in an environment with much higher jamming than a conventional code and carrier-tracking loops. The need to use conventional tracking loops as a transition tracking state to the ultratightly coupled processing limits the antijam performance. To improve the antijam performance in an electronically challenged environment, we seek a new method to initialize ultratight processing directly from acquisition without transitioning through conventional tracking loops.

Phase I: The contractor will develop an acquisition and/or ultratight processing approach that can directly transition from direct military signal acquisition to ultratight navigation processing. The algorithm will be tested via simulation to evaluate antijam performance improvement as compared to conventional mechanisms.

Phase II: The contractor will develop a prototype system that directly transitions from acquisition to ultratight GPS/INS tracking. The contractor will evaluate the system's ability to transition to ultratight coupling in the presense of increasing levels of interference to identify the limits iof it's capability. The Advanced Concepts Exploration (ACE) Laboratory can be made available to the contractor for several days to perform the system evaluation if desired. The ACE Facility at AFRL/SNRW has an integrated GPS/INS Hardware-in-the-Loop capability.

Dual Use Commercialization Potential: Upon completion of PHASE II, this effort will develop systems for integration into military platforms and weapons. The technology may also have application to commercial GPS systems used in ground and air transportation in areas of high signal blockage and multipath (cities, mountainous terrain, etc.).

Related References: Parkinson, Spilker, Axelrad, and Enge, "Global Positioning System: Theory and Applications Volume II," American Institute of Aeronautics and Astronautics, Inc., 1996

KEYWORDS: DCOP, Ultratight GPS/INS, Utratightly Cupled GPS/INS,Deeply Coupled GPS/INS, Deeply Coupled GPS/INS, GPS Acquisition, Direct Acquisition.

AF03-190 TITLE: Electromagnetic Compatibility/Interoperability Research Tools For Aging Aircraft COTS Insertion

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Aeronautical Systems Center (ASC)

Objective: Develop dual-use research tools for identifying/resolving aging aircraft Commercial-Off-The-Shelf (COTS) electromagnetic compatibility (EMC) interoperability issues

Description: COTS technology offers an affordable solution for the sustainment problems of aging aircraft. Utilization of COTS technology offers high savings in terms of procurement/sustainment lead times and costs. However, electromagnetic compatibility/interoperability issues between COTS technology and aircraft systems are one of the key challenges associated with COTS technology insertion. In general, EMC certification of COTS technology for military applications is time consuming and expensive. We seek creative approaches that lead to the creation of innovative, dual-use EMC research tools that enable the rapid/affordable identification/resolution of COTS EMC interoperability problems associated with COTS technology insertions for aging aircraft. The goal of this research is to evolve EMC research tools that enable the rapid identification/resolution of COTS EMC problems and the affordable insertion of COTS technology into aging aircraft. The dual-use technology base established by this research can be applied to developing COTS technology for both commercial and military applications.

Phase I: The Phase I effort will conduct the research required to define innovative, dual-use EMC research methodologies/tools that enable affordable COTS technology insertion to solve aging aircraft sustainment problems. The key objective of this research is to create innovative dual-use EMC research tools which enable the rapid/affordable identification/resolution of EMC problems associated with aging aircraft COTS technology insertions. The Phase I research will identify the critical technology challenges and define the Phase II approach for developing/demonstrating the required EMC research methodologies/technologies. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

Phase II: The Phase II effort will implement and demonstrate the critical EMC research methodologies/tools.

Dual Use Commercialization Potential: The EMC research tools can be implemented in government laboratories/facilities to identify/resolve EMC problems for aging aircraft COTS technology insertions. EMC research tools are dual-use technologies that have extensive commercial applications for resolving commercial product (radio, telecommunications, automotive) EMC issues. These EMC research tools can significantly reduce the risk/cost of COTS technology and the time to insert the technology into the marketplace. These same EMC research tools can be implemented in government laboratories/facilities for resolving EMC issues associated with aging aircraft COTS technology insertion.

Related References:
1. Kirchner, Edward L., and Salati, Bruce D. "EMC design approach for integrating COTS equipment into an existing military aircraft," Proceedings of the 1999 IEEE EMC Symposium on Electromagnetic Compatibility.

2. Joffe, Elya B., "Where are the government industries heading in a world of commercialization of EMC,? IEEE International Symposium on Electromagnetic Compatibility v 2, 1998.

3. Dixon, D.S., "Military use of commercial-off-the-shelf (COTS) equipment: Updated E**3 concerns," Proceedings of the 1997 10th International Conference on Electromagnetic Compatibility.

KEYWORDS: Electromagnetic Compatibility, Electromagnetic Interference, COTS, Aging Aircraft

AF03-191 TITLE: Missile Warning System Development Simulation Tools For Rapid Technology Insertion

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop dual-use simulation tools that enable missile warning system rapid technology insertion.

Description: Current research approaches for developing and inserting missile warning system technology require extensive opening air range testing that is both time consuming and cost prohibitive. Hardware-in-the-loop simulation provides a cost-effective approach that reduces development time and costs by providing a research methodology for evolving missile warning system technology in the laboratory. We seek creative approaches that lead to the creation of innovative, user-friendly, dual-use, hardware-in-the-loop simulation methodologies/technologies that enable missile warning system capabilities to be evolved/inserted through laboratory synthetic battlespace simulation. The goal of this research is to evolve affordable dual-use hardware-in-the-loop simulation technologies that increase the productivity of missile warning system development while reducing research costs. The dual-use simulation technology base established by this research will enable significant reductions in the time/cost for developing sensors for both commercial and military aircraft. This SBIR research addresses technology/tool needs for the DoD High Level Architecture (HLA) concepts/requirements being sponsored by the Defense Modeling and Simulation Office under the DMSO M&S Master Plan.

Phase I: The Phase I effort will conduct the research required to define affordable, dual-use, hardware-in-the-loop simulation methodologies/technologies for evolving/inserting missile warning system technologies. The key objective of this research is to create innovative, dual-use simulation technologies that increase the productivity of missile warning system research while reducing development costs and time. The Phase I research will identify the critical technology challenges and define the Phase II approach for developing/demonstrating the required hardware-in-the-loop simulation technologies. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

Phase II: The Phase II effort will implement and demonstrate the critical missile warning system hardware-in-the-loop simulation concepts/technologies.

Dual Use Commercialization Potential: Hardware-in-the-loop simulation technologies can be implemented in government laboratories and on test ranges to support the development/insertion of missile warning system capabilities. Hardware-in-the-loop simulation concepts/technologies that increase the productivity of missile warning system research and reduce development costs are dual-use technologies that have extensive commercial applications for markets such as the commercial aircraft sensor industries. Technology resulting from this topic can be used to evaluate candidate sensors and techniques to warn commercial and general aviation pilots about dangers from approaching aircraft. Resulting research will also have application in evaluating the effectiveness of sensors for assisting firefighters in locating people in smoky environments and could be used to demonstrate technology for evaluating energy efficiency of buildings (determining heat loss). These simulation concepts/technologies enable advanced sensors to be evolved/demonstrated in a laboratory environment which can significantly reduce risk/cost and the time to insert the technology into the marketplace. These same concepts/technologies can be implemented in government laboratories and on test ranges for military sensor research.

Related References:

1. Robinson, William G., "Development of a UV stimulator for installed system testing of aircraft missile warning systems,", Targets and backgrounds VI - Characterization, visualization, and the detection process; Proceedings of

the Conference, Orlando, FL, April 24-26, 2000 (A00-4990115-35),Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 4029), 190, p. 414-424 (2000)
2. Meyer, David J., Acevedo, Paul A. and O'Toole, Brian E., "Improvements to real-time ultraviolet scene simulation for sensor testing," Proceedings of the Conference, Orlando, FL, Apr. 13-15, 1998 (A99-14458 02-09), Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 3368), p. 310-320 (1998).
3. Danino, Meir, "The Missile Warning Challenge" Journal of Electronic Defense Jul 1999.
4. Makar, Robert J., and Howe Daniel B., "Real-Time IR/EO Scene Generation Utilizing an Optimized Scene Rendering Subsystem", Technologies for Synthetic Environments: Hardware-in-the-loop Testing V, Robert Lee Murrer, Editor, Proceedings of SPIE Vol. 4027, pp. 145-154, 2000.

KEYWORDS: Missile Warning, Simulation, Hardware-in-the-Loop

AF03-192 TITLE: Real-Time High-Fidelity Threat Simulation Capability

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Fighter Bomber (FB)

Objective: Develop a real-time high fidelity threat simulation capability for evolving situation awareness/response strategy technology.

Description: Innovative research is requested to evolve new leading-edge, high fidelity threat simulation technologies for developing advanced situation awareness/response strategy fusion technologies for next generation aircraft that utilize real-time information into the cockpit/real-time information out of the cockpit (RTIC/RTOC) concepts to execute missions. Current battlespace simulation technologies do not have the fidelity required to conduct the basic research, applied research and advanced technology development efforts to develop/transition RTIC/RTOC situation awarenesss/response strategy fusion technologies. These information fusion technologies are rapidly evolving into a new core research area that can provide significant improvements to the warfighter's ability to carry out time-critical missions through network centric warfare. These RTIC/RTOC technologies can provide the warfighter with a highly accurate assessment of the battlefield that can be utilized to provide improved threat warning/self-protection and to make real-time response/engagement decisions. Man/hardware-in-the-loop laboratory simulation is the most cost-effective prototyping methodology for maturing this type of technology because the battlefield can be brought to the laboratory, enabling precise control of test conditions. This laboratory synthetic battlespace simulation approach significantly reduces the time, risk, and cost associated with evolving/transitioning this type of advanced technology. The goal of this SBIR research topic is to develop leading-edge real time simulation technologies for conducting research to evolve advanced information fusion capabilities for next generation low observable aircraft. Current laboratory simulation technologies do not provide the required fidelity, real-time environment, and visualization. Advanced technology demonstrations in synthetic battlespace have limited productivity because the current simulation capabilities do not utilize the DoD High Level Architecture (HLA) concepts/requirements being sponsored by the Defense Modeling and Simulation Office (DMSO). Research is sought for developing the key real-time threat simulation technologies required to generate the dense high fidelity emitter threat environments needed to evolve situation awareness/response strategy capabilities that enhance the survivability of low observable tactical aircraft. This research will address simulator component technology challenges/barriers that limit the real-time generation of high fidelity threat waveforms in dense environments such as dynamic range/linearity limitations of radio frequency simulator amplifier/modulator components, waveform fidelity visualization/verification limitations and throughput processing limitations of digital signal processors. This research will also address the challenges for incorporating HLA standards, per the DMSO M&S Master Plan, into dense environment threat simulators for evolving situation awareness and response strategy capabilities.

Phase I: The Phase I effort will identify innovative real-time simulation technologies that enable demonstration of low observable situation awareness/response strategy technology in laboratory synthetic battlespace environments that utilize HLA architecture concepts to enable linked demonstrations via the HLA standards, a collaborative engineering technology concept currently in the recently revised Defense Technology Area Plan. The Phase I research will identify the critical simulation technology challenges and define the Phase II approach for developing/demonstrating the critical simulation technology required for low observable aircraft situation awareness/response strategy technology research in laboratory synthetic battlespace simulation facilities, such as the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL). Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

Phase II: The Phase II effort will implement and demonstrate the critical real-time simulation technology through linked simulation via the HLA standards per the DMSO M&S Master Plan.

Dual Use Commercialization Potential: The real-time simulation technology needed to evolve situation awareness/response strategy capability can be implemented in government laboratories and test ranges for the development and evaluation of advanced RTIC/RTOC capabilities. Real-time simulation technology is a dual-use technology that has extensive commercial applications for markets such as the communication and commercial space industries. This technology can be utilized to rapidly prototype advanced technologies for the commercial communication and space technology market. This rapid prototyping technology will reduce development costs and accelerate product movement to the marketplace.

Related References: Edward Eberl, "Changing Requirements for Threat Simulation," ADA 355202 22 Oct 98.

KEYWORDS: Real-Time, Simulation, Man-in-the-Loop, Hardware-in-the-Loop, Synthetic Battlespace

AF03-193 TITLE: Multi-sensor Registration Tools

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Develop multi-sensor autonomous registration technologies.

Description: Accurate and automated geo-registration is of interest to the United States Air Force. The objective of this effort is to develop innovative autonomous registration technology in the form of a software toolkit for the spatial alignment of image, signals intelligence (SIGINT), ground moving target indicator (GMTI) data collected from the battlespace. The focus of this research is the generic concept of a geo-reference invariant feature that can be extracted from each data source and the development of generic algorithms for correlating salient features across the multiple data sources and a fiducial database for relative and absolute registration. Examples features that cross multiple source data domains could be radio/TV transmission towers, command and control centers, road intersections, fixed search radar towers, and cellular phone towers. Trade-off studies will identify strategies for a reliable, flexible system that can tie disparate types of sensor data together, provide tractable error/uncertainty handling, and identify measures of effectiveness for automatic convergence to minimize human intervention. An equally important focus is the implementation of these algorithms as a software toolkit to enable the integration of different registration algorithms for multisource data.

Phase I: Develop and demonstrate a proof of concept for multisource data registration using salient features on a limited multisource data set that would be provided by the Government. Develop a software design that can be extended to integrate different algorithmic approaches based on a generic concept of a feature.

Phase II: Develop and integrate a complete suite of data registration algorithms in the form of a software toolkit. Characterize performance over a wide range of data including multisource imagery, GMTI, and SIGINT.

Dual Use Commercialization Potential: Military applications may involve platform or ground station georegistration services support. These georegistration services would enhance performance for various processes like targeting, tracking, fusion, and change detection. Autonomous data registration algorithms are needed in the growing area of Geospatial Information Systems (GIS) and geographic image analysis tools. The product of this effort can be integrated as a plug-in to commercial applications such as ESRI's ArcView and ERDAS IMAGINE to enable the automatic alignment of diffferent data sources.

Related References:

1. J Hackett, R Cannata, D Trask, W Clifton, "Multi-INT registration fusion," Proceedings of 2001 MSS Data Fusion Symposium, June 26-28, 2001, San Diego, CA.

2. L.G. Brown, "A survey of image registration techniques," Association for Computing Machinery, 1992, Vol. 24, pp. 325376.

3. F. Moffitt, and E. Mikhail, "Photogrammetry," 3rd Edition, New York, Harper and Row, 1980.

4. J. Ratches, C. Walters, R. Buser, and B. Guenther, "Aided and automatic target recognition based upon sensory inputs from image forming systems," IEEE Transactions on Pattern Analysis and Machine Intelligence, September 1997, Vol. 19, No. 9, pp. 1004-1019.

KEYWORDS: Image Registration, Geo-registration, Sensors, Signal Processing

AF03-196 TITLE: Space Based Optical Sensor Calibration Approaches

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space and Missile Systems Center (SMC)

Objective: Develop requirements/approach for, and demonstrate, compact/lightweight technology for on-board calibration of space-based optical sensors, to include multispectral and hyperspectral systems.

Description: Achieving superior calibration and accuracy for a space-based optical sensor once in orbit is a significant challenge. Most on-board optical sensors will utilize quantitative measurements for calibration that must be periodically updated against a standard to ensure its accuracy. Unless a measurement system is based on an instrument that operates as a primary standard, the accuracy of measurements cannot be assured, especially over a planned 5 to 10 year satellite lifetime. However, some future space-based systems have no plans to change their calibration approaches at this time.

Technological advances in optical sensors for military and commercial applications have allowed for the development of new systems with extremely high sensitivity requirements to include multispectral and hyperspectral sensors. While increased sensitivity is desirable, it is more important to have high confidence in the accuracy and functionality of many of the future systems. High confidence will provide good rationale on which to make important decisions, such as having to dedicate other assets to perform a more comprehensive analysis of a space object or terrestrial target, to take action to confirm and negate a threat through military action, etc. Currently, the National Institute of Standards and Technology (NIST) is in the process of building a standard blackbody and transfer radiometer to help calibrate ground-based equipment for initial setup of satellite systems before launch. Additionally, AFRL is studying alternative calibration techniques using astronomical sources to act as standards.

The technology for properly calibrating space systems before launch is being developed while no good system or development program is in place for NIST traceable calibration of space systems after launch. This topic calls for the development of a novel on-board calibration methodology to ensure that a sensor will meet its system performance requirements. The design must be low cost, low power consumptive, compact and lightweight.

Phase I: Develop calibration requirements for space-based optical systems to include multispectral and hyperspectral sensors. Investigate and assess existing calibration approaches and identify deficiencies. Develop a set of possible calibration approaches and recommend a subset to be evaluated during Phase II. Develop a Phase II program plan that includes a cost estimate.

Phase II: Design and fabricate a suite of calibration prototypes recommended in Phase I and demonstrate its performance.

Dual Use Commercialization Potential: The Air Force's Modernization Plan identified several possible acquisition programs would utilize this critical technology. In addition to support of future DoD acquisition programs, the technology developed under this SBIR effort can also be utilized in civil commercial systems, such as NASA's future space systems.

Related References:
1. Space Surveillance Sub-Mission Area Development Plan, Space Control Mission Area, SMC/XR, AFSPC, 2001

2. Strategy Master Plan for FY02 and Beyond, Air Force Space Command, 9 Feb 2000

KEYWORDS: Calibration, optical sensor, primary standard, multispectral sensor, hyperspectral sensor, transfer radiometer, astronomical sources

AF03-197   TITLE: <u>Passive Coherent Location (PCL) for Launch Vehicles</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Space and Missile Systems Center (SMC)

Objective: Demonstrate that a mobile PCL tracking system can accurately track launch vehicles.

Description: Future visions for space generally include the operation of reusable vehicles in areas beyond the boundaries of the current national ranges. An inexpensive method of tracking vehicles in new geographic areas will greatly facilitate the planned expansion. Preliminary testing of aircraft and the Space Shuttle have indicated that continuous wave technology may provide an all-weather, passive surveillance capability through the exploitation of reflected RF energy from commercial radio and television stations. Based on these tests an operational system, especially a transportable version, is limited by computer processing capability.

The goal of this program is to develop more efficient algorithms and utilize advances in computer processing speed and software design to develop a transportable system capable of providing sufficient accuracy to meet Eastern and Western Range safety requirements.

Phase I: Demonstrate feasibility of a mobile PCL tracking system. This would require development of an innovative algorithm that generates real-time trajectory data from the reflected RF energy and estimation of the launch vehicle's position and velocity accuracy. Identify COTS antenna equipment that would provide the necessary data. Provide weight and volume estimates of the complete system to demonstrate transportability.

Phase II: Demonstrate that the prototypical mobile PCL system, utilizing the recommended algorithms and hardware, meet the performance determined in Phase I. This can be done by either of two ways. The first method records the raw RF data at the launch site and then processes the data in a lab using the recommended algorithm and hardware. The second method installs the recommended hardware at the launch site and generates the trajectory data real-time. The contractor will propose which method (or an alternate method) will be used. If the desired hardware is too expensive then the contractor can use other hardware but must show that had the desired hardware been used the results would have been within the predicted value. Transportability will be shown by supplying a detailed layout of the equipment in each vehicle. Finally, if time and funding allows, the effect of near term advances in computer equipment on the system's size should be discussed.

Dual Use Commercialization Potential: PCL will benefit existing launch ranges by providing a tracking method with significantly lower costs than are associated with existing radars. More importantly, a transportable system will provide an important public safety benefit for commercial launches and/or launch vehicles operating outside the limits of the existing federal ranges. The system will also benefit other DOD facilities that are required to track aircraft or missiles by eliminating the needed for expensive ground based radars. Small controlled airports that presently do not have radar may benefit by using this system to get radar type information at significantly lower costs. Other small airports might be able to eliminate their radars thereby lowering costs.

Related References: none

KEYWORDS: Tracking and Surveillance, Continuous Wave Technology, Carrier Tracking, Mobile Tracking Systems, Passive Coherent Location.

AF03-198 TITLE: Single-Element Zoom Antenna

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop and demonstrate a high efficiency antenna element that generates ultralarge virtual apertures from a small physical structure, having a variable aperture size capability, suitable for space applications, and not requiring any specialized environmental conditioning support systems.

Description: Current spaceborne communication, navigation, and surveillance spacecraft employ sophisticated, single purpose phased array antennas for transmission and reception of radio frequency (RF) energy. As these phased array apertures become electrically/physically larger, they typically make use of distributed power throughout the array elements. While this approach has some advantages, the use of transmit/receive antenna modules (TRAM) also has a number of disadvantages. These arrays occupy large areas that tend to radiate heat rapidly into space. Keeping such distributed electronics warm is more difficult than cooling them. Any environmental requirements outside of the satellite bus are very costly. As these structures become larger (for very high gain applications) additional impacts occur to the satellite system, including shadowing of the solar panels, large moments impacting satellite dynamic control, etc. Each of these characteristics reflects back through the satellite system design, impacting size, weight, lifetime, and deployment cost.

It is desired to develop and demonstrate a radiating element that makes use of the unique environment of space to achieve an unusual form of operation: a very small physical size structure that can produce an electrically very large virtual aperture. It is desirable to have structures with a real-to-virtual aspect ratio greater than or equal to 40. An additional desirable operational capability is to be able to vary the effective radiating aperture, with an associated variation in gain appearing as a variable beam width, much like the optical zoom lens. This element should also provide a substantial deployment cost reduction over phased array, active tile antenna approaches.

The potential system level benefits of such a radiating element would include mass reduction, size reduction, reduced prime power and support, and substantial improvement in affordability.
Phase I: Design a radiating element that produces a large effective (virtual) aperture from a physically small package. Determine by analysis and simulation the anticipated antenna efficiency, the effective aperture amplitude/phase distribution, and the far field radiation pattern. Complete the mechanical design and a test plan to perform a proof-of-concept demonstration.

Phase II: Fabricate and demonstrate a prototype antenna that is applicable to some specific space based mission of the Air Force.

Dual Use Commercialization Potential: Application of this technology would permit the next generation commercial satellite communication systems to enjoy higher gain/higher effective radiated power (ERP) performance, at substantially lower cost than afforded by current technology.

Related References:
1. P.M. Morse and H. Feshbach, Methods of Theoretical Physics, Part I, McGraw-Hill Book Co.,Inc., New York, p. 837; 1953.

2. Kraus, John D., Antennas, McGraw-Hill Book Co. Inc., New York; 1988.

3. M. Cohn, et al, “TE Mode Excitation on Dielectric Loaded Parallel Plane and Trough Waveguides,” IEEE Trans. on Microwave Theory and Techniques, pp. 545-552; September, 1960.

KEYWORDS: Virtual Apertures, Variable Beamwidth Antennas, Focused Apertures

AF03-199 TITLE: Global Positioning System (GPS) Receiver

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop integrated GPS receiver not based on a Kalman filter and preferably less complex/computationally intensive.

Description: Most Global Positioning System (GPS) receivers employ Kalman filters to estimate the position and clock error. They also perform much of the signal tracking and detection in the time domain. The objective of this project is to develop a highly integrated receiver that uses some other approach. One example is to use a signal processing technique to separate GPS satellite signals using directional antennas. Another example is a purely software based receiver that operates in the frequency domain. Another example would be a kinematic carrier-phase architecture that is capable of handling high dynamics as experienced by a fighter aircraft. This may not be less complex, but would be an alternative method. The design should be able to continue to navigate in the presence of jamming.

Phase I: 1) Investigate technologies applicable to the design of an alternative highly integrated receiver. 2) Develop detailed models of candidate receiver algorithms. 3) Perform analyses/cost and trade studies. 4) Select final design based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of-concept demonstration to mutually (Air Force/contractor) agreed specifications. The basic focus would be a computer simulation of the design.

Phase II: 1) Produce detailed design of the alternative receiver. 2) Produce a production prototype receiver capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify receiver performance. The levels of jamming to be used during the tests will be determined mutually.

Dual Use Commercialization Potential: 1) Produce detailed design of the alternative receiver. 2) Produce a production prototype receiver capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify receiver performance. The levels of jamming to be used during the tests will be determined mutually.

Related References:
1. ION GPS-99, September 14-17, 1999

2. GPS Navigation using Neural Networks, M. Chansarkar, SiRF Technology

3. Static Carrier Phase Differential Positioning by Applying the H Infinity Filter, S. Sugimoto, Y. Kubo, T. Kindo, A. Ito, Ritsumeikan University, Japan

4. Accuracy and Integrity of Nonlinear Systems, P.B. Ober, Delft University of Technology, ION Technical Meeting, January 26-28, 2000:

5. A Comparison of an Optimal Global and a Suboptimal Decentralized Differential GPS/INS Filter for Relative State Estimation, W.R. Williamson, J. Min, J.L. Speyer, University of California, Los Angeles

6. An Inertial Navigation Data Fusion System Employing an Artificial Neural Network as the Data Integrator, M. Forrest, T. Spracklen, N. Ryan, University of Aberdeen, Scotland

KEYWORDS: Digital Signal Processing, Jamming, GPS Receiver, Noise separation, Kalman Filters, Signal Tracking/Detection

AF03-200 TITLE: Miniature Supercooled, Multiarm, Spiral, Antijam Controlled Reception Pattern Antenna (CRPA)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop a miniature, supercooled, multiarm, spiral CRPA

Description: Current CRPAs used for antijamming have a footprint (diameter) of 14.5 inches. The diameter is dictated by the number of elements, and the number of elements provide the degrees of freedom and quality of the nulls. Munitions require even more jam resistance but cannot afford the real estate of a 14.5-inch diameter plane. Recent development work has reduced the antenna size to 6 inches diameter. However, the 6-inch-diameter antenna contains only four elements while the 14.5-inch diameter CRPA has seven elements. Antenna research not related to the global positioning system (GPS) has demonstrated special spiral antenna arrays on the order of 1.5 inches in diameter. This size reduction was possible because of low-temperature supercooling of the antenna materials. A broadband, spiral, supercooled antenna design displayed bandwidth performance on the order 20 MHz. This test antenna was a two-arm (element) design however, additional arms (elements) would not significantly increase the approximately 1.5 inch diameter. The objective of this project is to develop an affordable supercooled multiarm spiral antenna that has a tenth the diameter (<2 inch) of current CRPAs. A miniature multielement (six to eight arms) antenna would enable beam-forming capabilities with a footprint suitable for small missiles and munitions. Supercooling the passive array allows comparable electrical performance with a small physical size. Investigations might involve cooling methods (possibly similar to those used on infrared (IR) seekers), bandwidth sufficiency for GPS alone or as a shared antenna with a data link, and a feasible number of arms (elements) traded against cost, feed complexity, footprint size, cooling issues and degrees of freedom.

Phase I: 1) Investigate technologies applicable to the design of a supercooled GPS antenna. 2) Develop detailed models of antenna designs. 3) Perform analyses/cost and trade studies. 4) Select final design based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of-concept demonstration to mutually (Air Force/contractor) agreed specifications.

Phase II: 1) Produce detailed design of the supercooled antenna. 2) Produce a production prototype antenna system capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify receiver performance.

Dual Use Commercialization Potential: Development of supercooled antenna systems has both DoD and commercial application in the future for GPS.

Related References:
1. P.M. Morse and H. Feshbach, Methods of Theoretical Physics, Part I, McGraw-Hill Book Co.,Inc., New York, p. 837; 1953.

2. Kraus, John D., Antennas, McGraw-Hill Book Co. Inc., New York; 1988.

3. M. Cohn, et al, “TE Mode Excitation on Dielectric Loaded Parallel Plane and Trough Waveguides”, IEEE Trans. on Microwave Theory and Techniques, pp. 545-552; September, 1960.

KEYWORDS: Superconductors, Supercooling, GPS antenna, Controlled reception pattern antenna (CRPA)

AF03-201 TITLE: Direct Transition from Acquisition to Ultra-Tightly Coupled GPS/IMU

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: To eliminate the dependency on conventional code and carrier tracking loops as a transition tracking state between direct military signal acquisition and ultra-tightly coupled Global Positioning System (GPS) / Inertial Measurement Unit (IMU) navigation in order to improve anti-jam performance.

Description: With the recent development of a new class of navigation algorithms called 'Ultra-Tightly Coupled GPS/IMU Navigation processing' (e.g., Direct Correlator Output Processing (DCOP), Ultra-Tightly Coupled (UTC), Deeply Coupled, Direct Measurement Processing (DMP), new levels of anti-jam performance are possible. Current navigation systems use conventional code and carrier tracking loops in their GPS receiver, which may be either loosely or tightly integrated with an inertial navigation system. Ultra-tightly coupled navigation systems appear to offer improved anti-jam performance as well as some other benefits compared to these conventional mechanizations. Currently, ultra-tightly coupled GPS/IMU systems must use a two-step process to achieve steady-state navigation. First, they go through an acquisition process, which must be a direct military signal acquisition for high anti-jam performance. Following signal acquisition, conventional tracking loops are used to pull in the signals to achieve steady state code and carrier tracking. At this point the state of the code and carrier tracking loops can be used to initiate ultra-tightly coupled processing. Current direct acquisition technology and ultra-tight systems can operate in an environment with much higher jamming than a conventional code and carrier tracking loops. The need to use conventional tracking loops as a transition tracking state to the ultra-tightly coupled processing limits the anti-jam performance. We seek a new method to initialize ultra-tight processing directly from acquisition without transitioning through conventional tracking loops to improve the anti-jam performance in an electronically challenged environment.

Phase I: The contractor will develop an acquisition and/or ultra-tight processing approach that can directly transition from direct military signal acquisition to ultra-tight navigation processing in a high jamming environment. The algorithm will be tested via simulation to evaluate anti-jam performance improvement as compared to conventional mechanizations.

Phase II: The contractor will develop a prototype system that directly transitions from acquisition to ultra-tight GPS/INS system in high jamming environments. The contractor will evaluate the system's ability to transition to ultratight coupling in the presence of increasing levels of interference to identify the limits of it's capability. The Advanced Concepts Exploration (ACE) Laboratory can be made available to the contractor for several days to perform the system evaluation if desired. The ACE Facility at AFRL/SNRW has an integrated GPS/INS Hardware-in-the-Loop capability.

Dual Use Commercialization Potential: Upon completion of PHASE II, this effort will develop systems for integration into military platforms and weapons. The technology may also have application to commercial GPS systems used in ground and air transportation in areas of high signal blockage and multipath (cities, mountainous terrain, etc.).

Related References:

1. Abbott, Anthony, Walter Lillo, and Randy Douglas. "Ultra-tight GPS/IMU Coupling Method: Proceedings of the National Technical Meeting of the Institute of Navigation, January 2001.

2. Erickson, John W. "Multiple Model Adaptive Estimation (MMAE) Applied to the Ultra-tightly Coupled IMU/GPS Methodology". Air Force Institute of Technology (AU), Wright-Patterson AFB, OH, November 2001.

KEYWORDS: DCOP, Ultra-Tight GPS/INS, Ultra-Tightly Coupled GPS/INS, Deeply Coupled GPS/INS, GPS, INS, GPS Acquisition, Direct Acquisition

AF03-202 TITLE: Adaptive Polarized Array Antennas

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop an adaptive antenna capable of simultaneous spatial and polarized filtering

Description: Global positioning system (GPS) user equipment that is fielded or is under development has addressed the need for interference rejection in numerous ways. Much work has been done in adaptive beam-forming (nulling and/or beam-steering) arrays for GPS. Some has been done in the polarization domain for a single GPS aperture (one horizontal and one vertical polarized element) and other applications. This work would attempt to combine these technologies to provide increased degrees of freedom in jamming rejection. The objective of this project is to develop an adaptive antenna capable of simultaneous spatial and polarized filtering. Signals from multiple pairs of linear-polarized orthogonal pairs of elements would be processed for improved antijamming (A/J) capability. This would enable rejection of interference at or above the horizon (spatial array contribution) and rejection of numerous sources of interference at the horizon only (polarization contribution).

Phase I: 1) Investigate technologies applicable to the design of an adaptive antenna system capable of simultaneous spatial and polarized filtering. 2) Develop detailed models of candidate antenna algorithms. 3) Perform analyses/cost and trade studies. 4) Select final algorithm based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of-concept demonstration to mutually (Air Force/contractor) agreed specifications. The basic focus would be a computer simulation of the antenna system while subject to jamming.

Phase II: 1) Produce detailed design of the antenna system. 2) Produce a production prototype system capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify antenna system performance with a receiver connected to antenna system. The levels of jamming to be used during the tests will be determined mutually.

Dual Use Commercialization Potential: The development of an adaptive A/J antenna system has both DoD and commercial application in the future for GPS.

Related References:

1. P.M. Morse and H. Feshbach, Methods of Theoretical Physics, Part I, McGraw-Hill Book Co.,Inc., New York, p. 837; 1953.

2. Kraus, John D., Antennas, McGraw-Hill Book Co. Inc., New York; 1988.

3. M. Cohn, et al, “TE Mode Excitation on Dielectric Loaded Parallel Plane and Trough Waveguides,” IEEE Trans. on Microwave Theory and Techniques, pp. 545-552; September, 1960.

KEYWORDS: Digital Signal Processing, Jamming, GPS Antenna, GPS Receiver, Controlled Reception Pattern Antenna (CRPA), Array Antenna

AF03-203 TITLE: Direct Initialization of Ultra-Tightly Coupled Weapons

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Space (SP)

Objective: Develop technology (algorithm, data compression, and data exchange concept) to allow a weapon with an ultra-tightly coupled Global Positioning System (GPS)/Inertial Navigation System (INS) implementation (Child) to initiate ultra-tight navigation using only data downloaded from a host vehicle (Parent) and without the child performing initial signal acquisition.

Description: With the recent developments of improved GPS/INS algorithms, such as direct correlator output processing, ultra-tightly coupled, deeply coupled, etc., many new capabilities are coming to light. Current weapon systems use conventional code and carrier tracking loops tightly integrated with an INS. The weapon's navigation system receives limited handoff information, i.e. position, velocity, and approximate time over the hosts system 1760 weapon system interface bus for initialization. The time accuracy varies with the specific mechanization (e.g., multiplex bus or high bandwidth line). After release, the weapon attempts to quickly acquire GPS signals and begin navigating before hitting the target. This process can be severely hampered if there is jamming while the weapon is attempting to acquire. In addition, the weapon navigation system must handle temporary signal losses immediately after release, due to the host platform blockage of the signal. Consequently, it is desired to be able to have the weapon navigating before release and to handle a temporary signal blockage immediately after release. A weapon equipped with an ultra-tight navigation system may be able to avoid signal acquisition after release and thereby provide much better anti-jam performance. Currently, ultra-tight GPS/IMU systems use conventional code and carrier tracking loops to transition from direct signal acquisition to ultra-tight mode. The ultra-tight filter follows or tracks the conventional tracking loops until its navigation solution stabilizes. Once the ultra-tight system is navigating, it can have a complete dropout of satellite signals for a short period of time and snap-back to resume tracking when signals return with no apparent loss of an accurate navigation solution. It is the objective of this program to develop an approach that allows the weapon (child) to directly enter the ultra-tight navigation mode, without a separate signal acquisition phase, using data from the launch platform (parent).

Phase I: The contractor shall develop the appropriate ultra-tight approach, ultra-tight initiating algorithm, and a notional interface data flow between parent navigation system and child ultra-tight navigation system. The parent will have either an ultra-tight or conventional navigation system. The results will be evaluated for both parent variants via simulation in typical weapon scenarios.

Phase II: Given a 1760 weapon interface between the parent and child navigation systems, the contractor will identify how to adjust the results from PHASE I to accommodate the real limitations imposed on data latency, bandwidth, and precision. Contractor will also identify any additional navigation filter state variables needed by the child ultra-tight system (such as parent/child time bias) or information from parent necessary to correct for these limitations. The contractor will then construct a child prototype ultra-tight GPS/INS system with a 1760 weapon interface for interfacing to the parent navigation system. The parent navigation system may be a real time or preprocessed GPS/INS simulation, but must generate the same data that would be available by an actual aircraft navigation system over a 1760 bus. An evaluation shall be carried out for both parent variants analyzed in PHASE I for typical weapon scenarios. Phase II: Given a 1760 weapon interface between the parent and child navigation systems, the contractor will identify how to adjust the results from PHASE I to accommodate the real limitations imposed on data latency, bandwidth, and precision. Contractor will also identify any additional navigation filter state variables needed by the child ultra-tight system (such as parent/child time bias) or information from parent necessary to correct for these limitations. The contractor will then construct a child prototype ultra-tight GPS/INS system with a 1760 weapon interface for interfacing to the parent navigation system. The parent navigation system may be a real time or preprocessed GPS/INS simulation, but must generate the same data that would be available by an actual aircraft navigation system over a 1760 bus. An evaluation shall be carried out for both parent variants analyzed in PHASE I for typical weapon scenarios. Since some weapon delivery platforms have niot installed the high bandwidth lines provided by the 1760 weapon interface, the proposed approach must not require the use of the high bandwidth lines (i.e., the 1553 multiplex data message subset of 1760 must be sufficient for the approach to work). The contractor wil evaluate the system's ability to transition to ultratight coupling in the presence of increasing levels of interference to identify the limits of its capability. The Advanced Concepts Exploration (ACE) Laboratory can be made available to the contractor for several days to perform the system evaluation if desired. The ACE Facility at AFRL/SNRW has an integrated GPS/INS Hardware-in-the-Loop capability.

Dual Use Commercialization Potential: Upon completion of PHASE II, this effort will develop this technology to allow fielding to weapon systems such as ERGM, Small Smart Bomb, etc. The technology may also have application to commercially available GPS systems used in ground and air transportation in areas of high signal blockage and multipath (cities, mountainous terrain, etc.).

Related References:

1. Abbott, Anthony, Walter Lillo, and Randy Douglas. "Ultra-tight GPS/IMU Coupling Method" Proceedings of the National Technical Meeting of the Institute of Navigation, January 2001.

2. Erickson, John W. "Multiple Model Adaptive Estimation (MMAE) Applied to the Ultra-tightly Coupled IMU/GPS Methodology". Air Force Institute of Technology (AU), Wright-Patterson AFB, OH, November 2001.

KEYWORDS: DCOP, Ultra-Tight GPS/INS, Ultra-Tightly Coupled GPS/INS, Deeply Coupled GPS/INS, GPS, INS, Timing Hand-Off

AF03-204 TITLE: Multiple Aperture Beam Tracking

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: Space (SP)

Objective: Efficiently manage multiple antenna apertures on a single platform to ensure continuous connectivity during beam handoff.

Description: Low profile, planar array antennas are ideal candidates for aircraft as they minimize the aerodynamic load, and simplify the installation. However, unfortunately, a single antenna can only provide +/-60 degrees of coverage, and thus several antennas located around the fuselage are necessary for complete coverage. This extended antenna coverage provides the ability to communicate in key regions of the world. However, coherent beam handoff between apertures is a key issue. The timing between the antenna phase centers must be established in order to hand off the antenna beam without losing data.

This effort is directed toward innovative approaches to switching between antenna beams to ensure continuous communication links as well as optimum link performance. Consideration should be given to leveraging ephemeris information, signal processing and calibration techniques to minimize the cost of installation and beam management hardware costs. This initiative is primarily directed toward UHF (Ultra High Frequency)(225 to 450 MHz) beam management; however, it applies to other DoD (Department of Defense) frequencies where multiple arrays with directive beams are employed. The technique must be capable of working with DAMA (Demand Assignment Multiple Access) waveforms. Antenna installation is a cost driver in the deployment of airborne terminals. Advanced processing can be applied to both minimize installation complexity and lower hardware costs. Development of this technology will directly benefit the implementation of the MUOS (Mobile User Objective System) and FAB-T (Family of Advanced Beyond Line of Sight Terminals) programs.

Phase I: Propose concept for multiple aperture beam tracking. Describe the hardware and software elements. Identify beam overlap requirements versus platform dynamics. Document performance projections.

Phase II: Develop concept prototype including hardware and software components. Identify alternative commercial solutions and compare the cost and performance. Demonstrate concept in the laboratory environment. Document the results.

Dual Use Commercialization Potential: Both commercial and military aircraft periodically employee beam hand off and could utilize advances in coherent beam handoff.

Related References:
1. Anon, 'Communications on the Move', Milcom '93 Conference Record, Volume 1 of 3, October 11-14, 1993

2. Franke, E., “UHF SATCOM downlink interference for the mobile platform”, MILCOM '96 Conference Record, Volume 1 , pp 22 –28, 1996

KEYWORDS: Aperture, Phased Array, Aperture Control, Beam Management, Phased Array, Mobile User Objective System

AF03-205 TITLE: GPS Spaceborne High Power/High Efficiency L-Band Sources

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Design/develop compact, high-efficiency, 250-watt L-Band microwave power sources for space, using developing microwave power technologies.

Description: Innovative approaches using advanced L-band (1-2 GHz) technologies are required for efficient, lightweight, microwave power sources for space applications. These technologies are required to support increased downlink transmitter power and satellite miniaturization requirements for future Block III Global Positioning Systems (GPS). Possible approaches which address high microwave power performance in small packages include wide bandgap technologies and microwave power modules (MPMs).

Recent development of a hybrid RF amplifier architecture, the MPM, combines the best features of both solid-state and vacuum technologies. This hybrid approach yields a cost-competitive amplifier that offers the power, efficiency, and bandwidth of a Traveling Wave Tube with the reduced noise and functionality of a solid-state amplifier. More significantly, this performance can be obtained in a miniaturized package that can be a small fraction of the size of a comparable output power TWT amplifier (TWTA).

Similarly, SiC MESFETs and GaN HEMTs on SiC have demonstrated extremely high RF power densities (W/mm), the ability to deliver high power (W/mm of gate periphery), and the ability to dissipate large amounts of thermal power (W/mm2 of die area). These previous demonstrations support wide bandgap transistor-based amplifiers as another potential approach for compact, high power microwave sources.

The proposed innovative technology should have the potential for accomplishing size and performance improvements over current technology. The current high power amplifier performance for the Global Positioning Satellite IIR-M is based on a GASFET design for a maximum of 175 watts output at a power-added efficiency of 44.3% in a 24 pound, 410 cubic inch package with a thermal density of 8.1 Watts/cubic inch. Power control and conditioning circuitry are also included in the 16 X 16 X 1.6 inch package.

Phase I: The Phase I effort should include the simulation/design of a novel, compact, efficient, reliable microwave power source for efficient integration and for space operation as required for systems such as GPS.

Phase II: Cost analysis for the L-Band prototype (and the production space-operation unit) should be included in the Phase II effort. An analytic model of the integrated power source should also be developed. The Phase II effort should conclude in the demonstration of the prototype L-Band power source.

Dual Use Commercialization Potential: The developed microwave sources will be of benefit to lightweight commercial/military satellites. GPS is a dual-use satellite constellation, with the L-band transmitter on each of the satellites providing ranging signals for both military and commercial uses. The military applications for the developed HPAs for the L-band transmitter focus on precision military air/land/marine navigation and weapon delivery. The L-band signals from the same transmitters service commercial space/air/land/marine navigation, surveying, and search and rescue operations.

Related References:

1. "Sixty-Percent-Efficient Miniature C-band Vacuum Power Booster for the Microwave Power Module," D. R. Whaley, C. M. Armstrong, B. Gannon, G. Groshart, E. Hurt, J. Hutchings, M. Roscoe, T. M. Antonsen, Jr, and B. Levush, IEEE Trans. Plasma Sci., vol. 26, pp. 912-921, Jun 1998.

2. "SiC MESFET with Output Power of 50 Watts CW at S-Band", R. A. Sadler. S. T. Allen, T. S. Alcorn, W. L. Pribble, J. Sumakeris, J. W. Palmour, L. T. Kehias, paper presentation at the June 1998 Device Research Conference.

3. “Global Positioning Systems: Theory and Applications, Volume I”, American Institute of Aeronautics and Astronautics, Inc., 1996.

4. “Improved Efficiency of Space-TWTs,” G. K. Kornfeld, Microwaves and RF, vol. 34, p. 111, Dec 1995.

5. “Orbital Performance of Communication Satellite Microwave Power Amplifiers (MPA's),” R. Strauss, Int. J. Satellite Com., vol. 11, pp. 279-285, Sep 1993.

KEYWORDS: Global Positioning Systems, high power amplifier, Microwave Power Module, wide bandgap

AF03-206 TITLE: Conformal Antenna Material Technology

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop/analyze flexible or paint-on materials for applicability to conformal communication antennas

Description: Installation of antennas on aircraft results in a significant portion of the total cost for a communications terminal. Large cutouts in the fuselage and protrusion into the airflow are two factors that have a direct impact on the antenna installation complexity and therefore cost. An approach to minimizing this cost would be to utilize conformal antennas applied directly to the fuselage. This effort is targeted toward development of conformal antenna or supporting materials for standard DoD frequency bands. Antenna characteristics include circular polarization. Material properties will be characterized, including relative dielectric constant, conductivity, and loss tangent as a function of frequency. An approach to incorporating the material into an antenna design should be described. Application of the antenna on the fuselage that is repeatable and reliable should be proposed. Approaches to extending the technology to larger, more directive antenna beams should be included.

A conformal antenna that can be directly applied to a platform has the potential to significantly reduce the installation costs for new antennas. Processes and materials are the focus of this effort. The material cost should not outweigh the benefits of the installation simplification. Minimum impact to the airframe is desired.

Phase I: Describe material alternatives for conformal antenna design. Fully characterize through measurement the dielectric substrate and the conductive material as a function of frequency. Identify dielectric application thickness capabilities. Define application approach, and identify any installation constraints. Design, analyze, and test an antenna element built from proposed dielectric and conductive materials. Identify the cost of the proposed materials.

Phase II: Build a prototype array of the antenna design from Phase I. Measure the performance and compare to comparable antenna built from standard commercially available materials. Performance will be evaluated against predictions. A report will document the gain and polarization as a function of frequency. Describe how the materials could be applied to larger antennas. Production costs and methodology will be described.

Dual Use Commercialization Potential: Both commercial and military aircraft could exploit advances in conformal antenna design.

Related References:
1. Carr, Joseph J., “Practical Antenna Handbook”, 4th edition, McGraw-Hill (May 23, 2001)

2. P. Bhartia, Inder Bahl, R. Garg, A. Ittipiboon, “Microstrip Antenna Design Handbook”, November 2000, Artech House

KEYWORDS: Conductive Materials, Conformal Antennas, Paint-On Antennas, Flexible Dielectrics,, Antenna Substrates, Aircraft Antenna

AF03-207 TITLE: Wideband Radiating Aperture

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Design/analyze multiband or wideband radiating aperture that enables flexible warfighter access to critical high data rate military and commercial communication assets.

Description: Airborne platforms are constrained in their ability to install additional capabilities by the available airframe real estate. In the past, each system on board has had a dedicated antenna. It is clear that this paradigm will no longer work. There is a pressing need to increase the capability of new antenna apertures through either wide band or multi-band performance. This initiative is to develop efficient multi-band or wide band radiating apertures covering commercial and military K-band reception, Ka-band commercial and military transmission, and Q-band military transmission. Polarization requirements include dual linear for creation of both left hand and right hand circularly polarized signals. The radiating aperture must be capable of installation in a low profile configuration on the airframe to minimize wind load. The array construction should lend itself well to available construction techniques. The design must be capable of performance through +/-60 degrees of electronic scanning.

Combination of communication signals, within a single aperture, has a multitude of benefits beyond simply providing greater capability within the available real estate. Limiting the modifications to the fuselage will reduce antenna installation costs. In addition, co-site issues that typically rely on antenna location on the airframe would be managed through hardware in the antenna. This could simplify costly co-site mitigation techniques. Integrating capability within a single mechanical structure can reduce hardware costs. Finally, the aircraft real estate problems will be alleviated. The majority of tactical and Special Forces aircraft have expressed the need to reduce the number of antennas on their airframes without sacrificing performance.

Phase I: Design and analyze wideband or multiband radiating elements. Indicate theoretical gain and frequency performance. Integrate the element model within a finite array lattice and predict antenna beam formation as a function of the scan angle and frequency. Polarization performance with scan angle should be characterized.

Phase II: Manufacture a subarray of elements and test. Performance will be evaluated against predictions. A report will document the gain and polarization as a function of elevation angle. Tuning of the elements to optimize the performance over the frequency of interest is desired. Production costs and methodology will be described.

Dual Use Commercialization Potential: Design can be applied to commercial satellite communication systems

Related References:
1. Steinberg Bernard D., "Principles of Aperture and Array System Design : Including Random and Adaptive Arrays" ASIN: 0471821020

2. Jull, "Aperture Antennas and Diffraction Theory", October, 1981

KEYWORDS: Multiband Antennas, K-band, Ka-band, EHF, Q-band wideband radiators, Interleaved arrays

AF03-208 TITLE: EHF Digital Beamforming Array Technology

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop phased array antenna architectures for use in space-based and airborne digital beamforming (DBF) phased array systems in the 71-86 GHz frequency range.

Description: Future geosynchronous satellite-based digital communications systems will likely operate in the 71-86 GHz frequency range to achieve higher bandwidths than currently available technology. These advanced SATCOM systems will require antennas that produce multiple simultaneous pencil beams for precise spatial diversity to enable frequency re-use, and to overcome atmospheric attenuation effects. Phased array antennas with 1.0 GHz instantaneous bandwidth are desired for this application. Digital beamforming is needed to generate and control potentially hundreds of independent beams, for both the 71-76 GHz satellite downlink as well as the 81-86 GHz uplink. Highly integrated channel hardware configurations are likely to be the key enabling approach for W-band DBF operation. Receiver technology needs to be tightly coupled with the analog-to-digital (A/D) conversion process, and transmitter technology needs to be tightly coupled with the digital-to-analog (D/A) conversion process. On transmit, digital generation of analog waveforms using look-up tables or direct digital synthesis (DDS) is vital and must be integrated with the transmitter channel configuration. The 1.0 GHz instantaneous bandwidth requirement mandates the use of wideband A/D converters or sub-banded approaches using multiple A/D converters to cover the bandwidth. Advanced parallel processing architectures based on DSP, FPGA, or ASIC chips must be integrated with the DBF phased array architecture in order to handle the enormous output sample data rate generated in each digital receive channel. Parallel processing beamforming algorithms are also key to this technology and may be implemented in software or in hardware as part of the overall array architecture.

Phase I: The Phase I activity shall include one or more of the following options: 1) Define and design the overall array architecture for either an uplink or downlink array, including the array size, number of beams (i.e. digital channels), EIRP or G/T, sidelobe levels, and possible use of subarrays, time delay, channel equalization and nulling schemes. 2) Define and design a parallel processing architecture that is tightly integrated with the array architecture and can support the receive sampled output data rate or the transmit waveform generation rate. 3) Design the digital channel hardware configurations including the receiver or transmitter, A/D or D/A, waveform generation on transmit, integrated processor chips, adopting either a full-bandwidth or sub-banded approach. 4) Use the combined outputs of tasks 1-3 to determine the area coverage performance on the surface of the Earth for a downlink array in geosynchronous orbit, or determine the scan coverage performance of an uplink array to a satellite in geosynchronous orbit. In either case, relate the features of the DBF array/processor architecture and channel configuration designs to spatial diversity, frequency re-use, number of users, channel isolation, and instantaneous bandwidth.

Phase II: Develop, fabricate and test an operational prototype array consisting of at least four digital channels built according to the array/processor/channel designs developed in Phase I. Testing shall include direct measurements of bit error rate and signal-to-noise ratio in each channel. Experimentally demonstrate the simultaneous use of two or more channels, and measure channel-to-channel isolation, and multi-user intersymbol interference, and relate the measured results to spatial diversity, frequency re-use, number of users, and instantaneous bandwidth.

Dual Use Commercialization Potential: W-band digital beamforming arrays will have significant utility for both military and commercial systems due to the wide bandwidth available for communication channels at W-band. High speed transmission of digital imagery, for military intelligence as well as numerous commercial applications, will benefit greatly from this technology. Automotive collision avoidance radars also operate in W-band, thus enabling potential spin-offs of this advanced DBF array antenna technology to the automotive industry

Related References:
1. Miura, R, et al," Beamforming experiment with a DBF multibeam antenna in a mobile satellite environment" Antennas and Propagation, IEEE Transactions on , Volume: 45 Issue: 4 , April 1997, Page(s): 707 -714

2. W. Chujo, et al, "Design Study of Digital Beamforming Antenna Applicable to Mobile Satellite Communications", Antennas and Propagation Society International Symposium, 1990. AP-S. Merging Technologies for the 90's. Digest. , 1990,Page(s): 400 -403 vol.1

3. H. Steyskal, "Digital Beamforming at Rome Laboratory", Microwave Journal, Feb. 1996

4. P. Barton, "Digital Beamforming for Radar", IEE Proc., Vol 127, Pt. F, No. 4, Aug 1980

KEYWORDS: Digital beamforming, phased array antennas, W-band, millimeter-waves, space-based digital communications

AF03-209 TITLE: Advanced W-Band AntennaTechnology

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Develop advanced antenna technologies for use in space-based and airborne communication systems in the 71-86 GHz frequency band.

Description: Future military satellite communications systems will need to operate at higher frequencies in order to meet the increasing demands for high data rates. Frequencies of 71-76 GHz for the satellite downlink and 81-86 for the uplink have been proposed to meet these future SATCOM (Satellite Communications) requirements. These systems will require advanced phased array antennas to produce multiple, simultaneous, high gain pencil beams, with capabilities for frequency reuse and anti-jam performance. They must also meet the stringent size and weight constraints for deployment in geosynchronous satellites and airborne platforms. Low cost is an additional consideration for wide deployment of these systems. The radiating aperture and beamforming network are key components of these systems, and new technologies are needed to meet the desired performance goals. At mm-wave frequencies the performance of conventional RF (Radio Frequency) radiators and feed networks is often degraded. Dielectric and ohmic losses increase dramatically at these frequencies, resulting in decreased antenna efficiency. Attempts to increase antenna bandwidth often reduce the efficiency further. In addition, wide impedance bandwidths do not necessarily provide wideband radiation performance, and can result in increased sidelobe and cross-polarization levels and reduced gain. The goal of this effort is to develop innovative designs for radiating elements and feed networks which achieve low loss, wide bandwidth and high efficiency antenna performance in a lightweight, compact, low cost design at these frequencies. Innovative radiators to consider might include new types of printed microstrip or slot antennas, slotted waveguides, dielectric rods, or substrate lens antennas. Use of novel, low-density substrates such as composites or flexible membranes should also be considered in the radiator concept.

Phase I: The Phase I effort shall include the following tasks: 1) Investigate innovative concepts for radiating elements and feed networks for the 71-86 GHz frequency band. Evaluate element performance, including bandwidth, losses, pattern characteristics, impedance matching, etc., as well as system integration issues such as weight, cost, fabrication tolerances and ease of integration with MMIC (Monolithic Microwave Integrated Circuit) or MCM (Multichip Module) components. 2) Develop a detailed design for a candidate radiating element for either the uplink or downlink array. Perform detailed studies of the element performance, including computer modeling of the element in an array environment. 3) Develop a concept for integrating these elements into an overall array architecture which will satisfy requirements for either the uplink or downlink system. Include in the array design the total number of elements, the array feed or beamforming network (including the possible use of subarrays), sidelobe levels, number of beams, and integration of the radiating aperture with other system components. Analyze the performance of this array in terms of bandwidth, gain, and scan performance.

Phase II: Use the design selected in Phase I to fabricate a small-scale operational prototype of the radiating array. The design and size of the prototype array shall be adequate to demonstrate the radiator performance in an array environment suitable to the selected SATCOM function. The prototype will be thoroughly tested, including input impedance, radiation patterns, and directivity, and performance will be characterized relative to its ability to meet the radiator requirements for future satellite communication systems.

Dual Use Commercialization Potential: The demand for high quality multimedia information services is rapidly increasing in both the military and commercial sectors. The crowding of the spectrum at lower frequencies, combined with an increasing number of users and higher bandwidth requirements are driving both sectors to higher frequencies. The mm-wave SATCOM antenna technology will have commercial uses for broadband multi-media, high speed internet connections, and mobile broadband communications.

Related References:

1. Grzyb, J., et al, “MM-Wave Microstrip and Novel Slot Antennas on Low Cost Large Area Panel MCM-D Substrates – a Feasibility and Performance Study”, Proc. 2001 Electronic Components and Technology Conference, May 2001, pp. 331-338.

2. Farserotu, J.; Prasad, R, “A survey of future broadband multimedia satellite systems, issues and trends”, IEEE Communications Magazine, vol. 38, issue 6, pp. 128 –133, June 2000.

3. Rebeiz, G. M., "Millimeter-wave and terahertz integrated-circuit antennas," IEEE Proceedings - Special Issue on Space Terahertz Technology, vol. 80, no.11, pp. 1748-1770, Nov. 1992.

4. Nesic, A., et al, “Antenna Solution for Future Communication Devices in mm-Wave Range”, Proc.TELSIKS 2001, Sept. 2001, pp. 194-202.

5. Wu, X., et al, “Design and Characterization of Single- and Multiple-Beam MM-Wave Circularly Polarized Substrate Lens Antennas for Wireless Communications”, IEEE Trans Microwave Theory Tech., vol. 49, no. 3, Mar. 2001, pp. 431-441.

KEYWORDS: Antennas, phased arrays, satellite communications, millimeter-waves, radiators, multi-beam antennas

AF03-210 TITLE: Efficient and compact Electron Sources for Advanced Communication Devices

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: Space (SP)

Objective: Manufacture efficient and compact electron sources based on recent advances in microtip array and planar cathode technology.

Description: The ability to fabricate efficient and compact electron sources for use in communication devices, in particular traveling wave tubes, will have numerous applications in military and commercial systems. For the most commonly used electron sources, i. e. thermionic cathodes, to operate properly, they have to be heated to high temperatures, which consumes energy and reduces long-term reliability. Having electron sources that can operate without heating (cold cathodes) will have significant impact on the development of future space communication components and systems.

This SBIR topic seeks to develop the technology for the manufacture high current electron sources based on the recent advances in the areas of microtip arrays and low electron affinity materials. The goals are to develop the technology and scientific underpinning that is required to fabricate such microtip array cold cathodes and to provide the infrastructure for their manufacture and insertion into military and commercial applications.

Phase I: Design/fabricate prototype to demonstrate the concept of high current electron sources that require no heating. Target geometric current densities for the prototype should be 10 to 100 amps/sq. cm. Gather and analyze performance data on prototype cold cathodes. Develop a theoretical model to improve the efficiency of the device.

Phase II: Refine the design and materials system to enhance the efficiency, reliability and current density of microtip array cold cathodes. Use model predictions and actual measurements on prototype to design/fabricate an engineering model device. Prepare a manufacturing and commercialization roadmap to market the technology.

Dual Use Commercialization Potential: Microtip array cold cathodes offer numerous opportunities for enhancement in both military and commercial applications. They are particularly advantageous in applications where an intense controlled electron beam is desired, such as traveling wave tubes, radar transmitters, displays, etc.

Related References:

1. E. G. Wintucky, et al, Proceedings of the Second International Vacuum Electron Sources Conference, Tskuba, Japan, Tskuba Information Laboratory, Inc., 1998

2. J.J. Hren, Proceedings of the 11th International Vacuum Microelectronics Conference, Piscataway, NJ, IEEE, Inc. 1998

KEYWORDS: Electron Sources, Cold Cathode, Self Emission, Microtip Array, Field Emitters.

AF03-211 TITLE: <u>Innovative Antenna Tracking for Mobile PlatformsS</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Develop common antenna interface to facilitate cost-effective upgrades and new technology insertion

Description: The antenna to terminal interface for directive antenna beams on mobile platforms includes power, commands, RF signals, and tracking information. Of these signals, the tracking information is the most difficult to standardize as it involves a control system that bridges the terminal and antenna units. Tracking directive antenna beams on mobile platforms require stabilization to ensure the communication links are maintained throughout platform dynamics. This is done through the use of a closed loop tracking system. The control loop generally utilizes inertial sensors to compensate for quick platform motions. However, inertial sensors drift in accuracy. Through sequential sampling of the receive signal level the drift can be eliminated. Standardize of the antenna to terminal interface for directive, stabilized antennas would enable a multitude of antenna manufacturers to develop antennas for a given communications terminal.

This effort will examine the antenna to terminal interface. Approaches to simplifying the interface will be explored with an emphasis on enabling a software modification to the tracking control for new antenna systems. The goal is to simplify the interface to allow for a software modification to the terminal when changing between antennas. This technology will prove useful to aircraft communications over the GMSP (Global Multi-Mission Service Platform) and Advanced Polar Systems.

Phase I: Identify current and proposed antenna to terminal interface. Identify information crossing the interface. Provide simulation of the antenna beam stabilization and demonstrate how software modification is adequate when upgrading the antenna system. Address whether it is viable to eliminate the tracking interface element, and identify the associated risks.

Phase II: Prototype the critical elements of the antenna interface defined in Phase 1. Perform a laboratory demonstration of the concept. Compare the results with theoretical. Identify interface separation, accuracy, latency, and frequency limitations. Identify hardware requirements and associated cost.

Dual Use Commercialization Potential: Commercial application to aircraft direct TV market

Related References:
1. R. B. Dybdal, “User Segment Antenna Development Issues,” 1998 IEEE MILCOM Symposium Digest, Boston MA, pp 294-297 (Classified volume), October 26-30, 1998

2. Lindbom, Lars, “A Wiener filtering approach to the design of tracking algorithms : with applications in mobile radio communications”

KEYWORDS: Beam Stabilization, Layered terminals, Antenna Tracking, Antenna interface, Telecommunications, Terminals

AF03-212 TITLE: Representation for Enhanced Sensor Exploitation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: Command & Control (C2)

WARFIGHTER IMPACT: By adapting onboard sensors to automatically account for changing battlefield conditions, sensor effectiveness may be greatly enhanced. Sensor moding, pointing, and controlling actions are candidate adaptation strategies. Building an adaptation system requires a mathematical representation of the sensing structure, comprised of models for the sensors themselves, the system that accrues their data, and the resource manager that controls them.

OBJECTIVE: The objective of this program is to develop a mathematical framework and associated algorithms for fusing sensor measurement data that integrates well with the need to perform adaptive, real-time sensor resource management.

DESCRIPTION: Current sensor systems enable a small number of pre-set sensor control modes which are selected by the operator or pilot and which allow limited automated response to the sensed data. For example, the F-15E has about two dozen air-to-air and air-to-ground radar modes that can be selected by the pilot or weapon systems officer. These include various search, track, mapping, and electronic counter-measure modes. In some cases the sensor controller has a simple automatic response (e.g., to lock track on a designated target).

Except for the automation of a few simple tasks, current approaches to sensor resource management (SRM) are manual. These approaches depend on a human operator interpreting displayed information from tracking systems, imagery, etc. and then selecting changes in sensor control settings. This situation limits the sensor control response to the speed of human reaction, and does not allow adapting the response to measured attributes of the data. Sensor systems under development (e.g., RTIP and JSF radar systems) have new modes (GMTI, HRR, higher resolution SAR) and capabilities that are beyond a human's ability to control fully, modes that serve to increase the need for developing automated sensor controls. Successful development of real-time adaptive sensor control will multiply the effectiveness of new sensors relative to continuing the present approach.

In addition, current representations and algorithms for sensor resource managers (SRMgr) have focused only on collecting kinematic and identification information about individual objects (i.e., for Level 1 fusion), rather than on collecting information to expose higher level military units, situations and their meaning. There is need to develop SRMgrs that take direction from outside sources like operator queries, that recognize their limits and know when to seek help, and that respond to all aspects of the world state, including the situation estimate.

Past efforts to design a better SRMgr have often fallen short of their goals because the mathematical framework was designed exclusively for tracking or identity estimation, and did not represent the broader data fusion problem with sufficient fidelity to serve the needs of the SRMgr. In terms of goals and constraints, the new framework and algorithm must: 1) recognize that data fusion and sensor resource management must work together to produce a viable system solution; 2) allow for both physical and statistical models of sources and systems; 3) recognize that tracking requires feature-assisted methods to differentiate objects and maintain object continuity, and that using such methods levies additional tasks on the sensors; 4) facilitate assimilation of data from sources with very different apertures; 5) account for the complex and heterogeneous nature of the information space (spatial, time, objects, groupings, etc); 6) include a calculus that estimates a world state and extracts a useful depiction of it; and 7) operate with on-line algorithms that are scaleable, tractable, and consistent; . The new representational framework and algorithms would address fundamental and pervasive issues that are critical to creating a viable infrastructure for simultaneously fusing data and managing the data production assets.

PHASE I: Develop and demonstrate a representation for continuously tracking and identifying objects that also provides an effective framework for managing the sensors that deliver object observations. Develop an algorithmic structure to implement this representation that is scaleable, tractable, and consistent. Demonstrate performance of the new algorithms via simulation in a prototype system involving a few sensors on a single platform operating against a small number of targets.

PHASE II: Continue development of integrated software for continuous tracking, identification, and sensor resource management, conducting tradeoffs of alternative implementations to assess the best avenues to achieve balanced performance gains. Characterize system performance against stressful scenarios using a variety of real and simulated data sets where there is both a dynamically evolving set of information needs and urgencies, and a changing set of sensing resources. Demonstrate SRMgr performance against an application chosen for its diverse sensor mix across multiple platforms, for the wide range of client demands on the system, and for the dynamically evolving nature of its imperatives and taskings.

DUAL USE COMMERCIALIZATION POTENTIAL:The customers for adaptive sensor control technology include all future developers and users of agile, multi-mode airborne radar systems, both tactical and ISR aircraft. Surveillance and reconnaissance systems with new radars can utilize the technology to increase the effective footprint of an ISR platform. Tactical systems can utilize adaptive sensor control to reduce pilot workload while increasing situational awareness. There are also significant applications to non-military surveillance systems such as those needed for enhanced security. Examples include monitoring of airports, border crossings, power plants, and other sensitive public facilities. In particular, these systems utilize video cameras that can be pointed and zoomed to track and identify people and vehicles, and these systems can benefit from SRMgr automation like that for military systems.

References:
1. D. Penny, M. Williams, "Sequential approach to multi-sensor resource management using particle filters", Signal and Data Processing of Small Targets 2000, Proceedings of the AeroSense Conference, Orlando, FL, Apr. 24-27, 2000.
2. Robert Popp, A.W. Bailey, J.N. Tsitsiklis, "Dynamic airborne sensor resource management for ground moving target tracking and classification", 2000 IEEE Aerospace Conference, Big Sky, MT.

KEYWORDS: Mathematical Representation, Sensor Resource Management, Consistent Operational Picture.

AF03-213 TITLE: Robust Contingency Planning For Multiple ISR Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Command & Control (C2)

Objective: To develop methods and tools which produce pre-mission collection schedules for multiple Intelligence, Surveillance, and Reconnaissance (ISR) assets while maximizing responsiveness to unexpected events

WARFIGHTER IMPACT: The ability to construction robust, efficient, and adaptive collection schedules for Intelligence, Surveillance, and Reconnaissance (ISR) assets will provide greatly improved surveillance capabilities for time-constrained situations (such as identifying, localizing, and prosecuting high value targets) and will aid in extended operating conditions (such as classification of targets in foliage). This will also provide capability to take advantage of "pop-up" surveillance opportunities in the battlefield.

Description: Modern Intelligence, Surveillance, and Reconnaissance (ISR) missions demand flexible allocation of resources. Thus, Dynamic Retasking has become a critically important requirement for modern ISR assets. The ability of a collection of sensor platforms to respond to retasking commands is limited by aspects of mission construction (such as asset routing, surveillance collection schedules and other sensor utilization issues) that arise during pre-mission planning. Mission planning tools that hedge against uncertainty by considering multiple contingencies are required to address an increasingly agile threat environment encountered in the modern battlespace. Ideally, these tools would develop flexible plans which can accommodate changes due to unforeseen events. Although decision aids for multi-platform ISR collection mission planning have been developed, these support planning for wide area surveillance and regular collection against fixed targets. But, in realistic situations numerous "pop-up" events may occur (new targets, cross-cues, new surveillance needs, etc). Often there is inadequate time available to develop alternate collection plans that consider time constraints, task precedence, and platform capabilities/risk while minimizing perturbations to planned platform routes. This effort seeks to develop an alternative approach capable of planning collection missions that hedge against a broad range of contingencies while maintaining efficient sensor utilization and coverage. For example, it would be desirable to improve sensor utilization over multiple surveillance areas, while maximizing the ability to service pop-up events in certain critical areas. Such tradeoffs can be evaluated during mission planning by exploiting knowledge of expected events (e.g., the probability of certain events occurring can be reliably estimated given sufficient data). The primary goal of this topic is to develop algorithmic methods facilitating the development of a multi-asset pre-mission planning tool. This tool should construct platform routes and surveillance schedules while anticipating contingencies (i.e. so that sensors are positioned to enable effective response to selected contingencies). The proposed solution must reconcile multiple tradeoffs that arise in balancing platform risk, sensor utilization and collection coverage and responsiveness to immediate cross-cues.

Phase I: Develop and demonstrate a prototype contingency planning algorithm and demonstrate efficient replanning capabilities for a limited set of ISR missions. Identify options for simulation and evaluation of collection plans with cross cueing. Interact with government to define scenarios and asset models of interest.

Phase II: Design and develop an ISR mission planning software system that utilizes optimization methods for contingency ISR mission planning. Develop a simulation environment to evaluate effectiveness and enable transition of the enhanced contingency mission planning system. Complete a simulation analysis to characterize replanning performance under a range of cross cueing scenarios and surveillance missions.

Dual Use Commercialization Potential: Commercialization/Dual Use Applications: Flexible scheduling and planning systems have applicability to real-world systems plagued by unpredictable events. Examples include airline scheduling, package delivery scheduling, power distribution and generation systems, and modern, automated manufacturing systems.

Related References:
1. J. Manyika and H. Durrant-Whyte, "Data Fusion and Sensor management: An Information Theoretic Approach", Prentice Hall, 1994.
2. S. Blackman and R. Poploi, "Desihn and Analysis of Modern Tracking Systems", Artech House, 1999.
3. S. Musick and R. Malhotra, "Chasing the Elusive Sensor Manager", NAECON '94, Dayton OH, May 1994.
4. K. Kastella, "Discrimination Gain to Optimaize Detection and Classification", IEEE Journal on System, Man and Cybernetics, Jan 1996.

KEYWORDS: Scheduling, Planning, Intelligence, Surveillance, and Reconnaissance (ISR), Collections Management, Multi-objective Optimization

AF03-214 TITLE: Active Management of Multiple Sensors & Platforms for Synchronized ISR

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Command & Control (C2)

Objective: Develop a system concept to manage execution of synchronized collection schedules across multiple ISR platforms.

WARFIGHTER IMPACT: Allow automatic replanning of ISR missions, thus providing more accurate and timely information to tactical commanders.

Description: Certain airborne ISR missions require coordination of multiple ISR sensors aboard multiple platforms to maintain continuous coverage of surveillance regions. Continuous surveillance coverage is important to provide confident battlefield situation estimates to tactical commanders. Multiple-asset ISR planning tools develop synchronized routes and sensor schedules consistent with sensor resource and utilization limits. Current planning tools require hours or days to develop plans, thus they lack the needed flexibility to adapt to changes in the mission environment. If a few targets move, the plans may be flexible enough to accommodate the needed changes. If, on the other hand, a platform is not available, or there are large amounts of target movement (a time when surveillance is most needed), the plans would no longer meet the need to provide surveillance coverage. To achieve continuous coverage will require a capability to maintain synchronization of collection plans over the duration of an extended surveillance mission. Achieving continuous coverage over large surveillance regions using a limited number of airborne assets will require both coordinated collection planning and active management of plan execution to maintain sensor synchronization. In addition, certain high priority, synchronized multi-platform collections may be required for targeting using the same assets.

Many high priority surveillance and targeting missions require synchronization of airborne ISR collections. For example, a Ground Moving Target Indicator (GMTI) sensor may encounter blind spots due to platform turns and terrain masking. The resulting interruption in Ground Reference Coverage Area (GRCA) coverage could be avoided by coordinating coverage from one or more platform sensors. Special multi-platform ISR collections such as Signals Intelligence (SIGINT) geolocation Time Difference of Arrival (TDOA) and multi-lateration radar measurements require very precise time-line synchronization. Current software produces a coordinated plan, but maintenance of collection plan execution has been difficult to achieve due to minor perturbations (i.e. wind may cause one platform to arrive slightly late) even in controlled field tests. Such plans are prone to a domino effect, where a minor perturbation early on makes the execution of the rest of the plan impossible. The goal of this topic is to develop collection plan management tools and a control concept to enable active resynchronization of collection plans by sharing platform collection status and navigation reports. Such "live data" reports (e.g., Precise Participant Location and Identification (PPLI)) could be used within an automated replanning framework to resynchronize the collection plan in the face of execution perturbations, thus overcoming the domino effect. Approaches to solution include but are not limited to: Dynamic replanning, competitive bidding agents, neural networks, genetic algorithms, and traditional search space appraches.

Phase I: Perform a study to identify sources and extent of plan de-synchronization for representative surveillance missions and develop concept collection management architecture that enables active collection plan updating for plan resynchronization. Identify planning and replanning algorithms and demonstrate computational tools consistent with the control architecture framework. Evaluate coverage performance improvement from active resynchronization for representative surveillance missions.

Phase II: Develop a prototype ISR mission plan management concept system. Demonstrate capability to maintain synchronization of multi-asset collection plans and maintain surveillance coverage. Complete a system demonstration that evaluates performance of active synchronization algorithms and software components using a simulation test bed.

Dual Use Commercialization Potential: Airborne sensor surveillance systems are increasingly playing a role in land use survey, traffic monitoring, and border surveillance for a range of commercial applications.

Related References: none

KEYWORDS: Tracking, Multi-INT Fusion Algorithms, Correlation, Data Alignment (spatial and temporal) Algorithms

AF03-215 TITLE: Continuous Identification Sensor Management

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: Command & Control (C2)

Objective: The objective of this effort is to develop an automated real-time sensor manager that improves continuous tracking and identification of ground targets in multiple-target tracking environments.
WARFIGHTER IMPACT: Improves war fighter decision making by improving battlefield situational awareness. Also improves time critical targeting capability by maintaining track and identification of mobile targets.

Description: With electronically steered array (ESA) radars and high speed digital processing, airborne radar systems will be able to control wave forms and steer beams at the single pulse level. However, except for a few simple automated tasks, current approaches are essentially manual. They depend on a human operator interpreting displayed information from tracking systems, imagery, etc. and then selecting changes in sensor control settings. This approach limits the sensor control response to the speed of human reaction and does not allow adapting the response to measured attributes of the data. New sensor systems under development have new modes (Ground Moving Target Indicator (GMTI), High Resolution Radar (HRR), higher resolution Synthetic Aperture Radar (SAR)) and capabilities beyond human ability to control fully and it is necessary to develop automated sensor controls that can fully exploit these new capabilities. The objective of this Small Business Innovation Research is to develop strategies to control multi-mode sensors in response to real-time information from the sensor's tracking, fusion, and target recognition systems, to multiply the effectiveness of these sensors to react to clutter, interference, and difficult tracking situations as compared to using conventional, pre-set sensor controls. For instance, based on target signature results, a target report may have come from a significant target so increase it's priority for kinematics and identity updates. Another example is adjusting sensor usage based on expectations that a priority target will be lost due to obscuration or it is falling below minimal detectable velocity. Perhaps a short dwell SAR could be scheduled to make sure the target didn't stop. Perhaps a longer dwell SAR could be scheduled to get get good signature information to support moving to stationary target signature association. Judicious scheduling of type, time, and location of measurements will improve track purity and continuity and thus identification performance. Unique and emphasized by this effort is construction of collection geometries to support signature aided tracking as well as moving target ID functions. In particular, signature aided tracking requires the sensor manager to collect signatures at the right geometries to support tracking association problems. Databases must be populated on the fly to allow confident association of a track to new reports. Very related to this is the need to collect signatures at the right geometries to get good ID performance. Successful development of real-time adaptive sensor control will multiply the effectiveness of new sensors relative to continuing the present approach to sensor control because more tasks can be performed by a single sensor platform and air crew with adaptive sensor control than with conventional sensor control.

Phase I: Phase I could include defining and analyzing a real time adaptive sensor control in the context of controlling GMTI, SAR, and HRR modes to maintain continuous track and identification of vehicles that move and stop. The analysis could use low-level radar models of future multi-mode radar.

Phase II: Phase II could demonstrate feasibility using a high fidelity simulation of realistic sensor, processing, and feedback control processing. Phase II would likely include characterizing performance for a variety of conditions relevant to mission scenarios i.e. target density, obscuration levels.

Dual Use Commercialization Potential: The technology that will be developed under this program will apply directly to advanced radar systems such as those being developed for RTIP. In addition, commercial systems for traffic monitoring are under development, and the technology developed under this effort could be extended for those applications.

Related References:
1. J. Manyika and H. Durrant-Whyte, "Data Fusion and Sensor management: An Information Theoretic Approach", Prentice Hall, 1994.
2. S. Blackman and R. Poploi, "Design and Analysis of Modern Tracking Systems", Artech House, 1999.
3. S. Musick and R. Malhotra, "Chasing the Elusive Sensor Manager", NAECON '94, Dayton OH, May 1994.
4. K. Kastella, "Discrimination Gain to Optimize Detection and Classification", IEEE Journal on System, Man and Cybernetics, Jan 1996.

KEYWORDS: Sensor Management, Feature Aided Tracking, GMTI, SAR

AF03-216 TITLE: <u>Combining Unattended Ground Sensor & ISR Information for improved SA</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: Command & Control (C2)

Objective: To develop methods which effectively combine information from unattended ground sensors (UGS) with Intelligence, Surveillance, and Reconnaissance (ISR) assets to enable improved situational awareness.

Description: The projected use of Unattended Ground Sensors (UGS) has risen in recent years. UGS may be planted by friendly personnel or air-dropped to desirable locations. These ground sensor systems facilitate remote sensing of hostile or protected areas and provide capabilities that are complementary to those of overhead intelligence, surveillance, and reconnaissance (ISR) assets. UGS may aid in the detection and tracking of objects in urban and foliated areas that are not easily observable by overhead assets. UGS provide object type information that is semantically comparable to that available from overhead ISR systems but operate with different capabilities and performance constraints (e.g., performance varies with object proximity to sensor, echos can complicate acoustic sensing, etc.). Synergistic use of UGS and ISR assets may help to increase detection performance, maintain target tracks (reduce track fragmentation), improve target classification, and expand situational awareness. Aside from providing ground-based observations, UGS also provide various sensor types (acoustic, magnetic, seismic, or simple imaging sensors) complementing typical ISR sensor types. The inclusion of evidence from these alternative, ground-based sensors may provide valuable information when targets are obscured, partially occluded, or not visible to overhead assets. This may greatly improve situational awareness in extended operating conditions. The goal of this effort is to develop principled methods for decision-making (detection, classification, and tracking decisions) while combining information from UGS with that of overhead ISR assets.

Phase 1: Develop models for sensor performance of various UGS sensor types. Develop concepts for integrating UGS and surveillance asset data in suitable applications involving object detection and tracking (including defense-related scenarios as well as commercial applications).

Phase 2: Mature concepts developed in Phase 1. Develop prototype system software for integrating UGS data with surveillance data to produce detections and tracking of objects. Characterize performance via simulation using real data to the extent possible for a variety of mission scenarios. Demonstrate complete prototype.

Dual Use Commercialization Potential: Advanced ground stations and platforms that have multisource data links currently exist and are being upgraded to include multisource tracking and exploitation tools. The technology that will be developed under this program will apply directly to those systems. In addition, commercial systems for security and surveillance, as well as traffic monitoring are under development; The technology developed under this effort could be extended for those applications.

Related References:
1. L.B. Scotts, "Unattended Ground-Sensor Related Technologies", Proceedings of SPIE 2000, Orlando, FL, April 26, 2000
2. "Unattended Ground-Sensor Related Technologies and Applications (I and II)", Proceedings of SPIE 2000, Orlando, FL, April, 2000
3. S. Blackman and R. Popoli, "Design and Analysis of Modern Tracking Systems", Artech House, 1999.
4. E. Waltz and J. Llinas, "Multisensor Data Fusion", Artech House, 1990

KEYWORDS: Unattended Ground Sensor; Sensor Fusion; Target Tracking; Target Detection; Automatic Target Recognition

AF03-217 TITLE: <u>Synthetic Signature Prediction and Feature Analysis for Recognition Applications</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

Objective: Develop physics-based feature spaces for targets in terrain to support target recognition and fusion modeling and simulation.

Description: The Air Force Research Laboratory (AFRL) is actively pursuing physics-based algorithm development for the detection and identification of moving and stationary ground targets in scene settings, including tree regions. Exploratory research in the area of physics-based feature characterization of target and background radar signature data is sought with the goal of improving radar sensor and processing development for target detection, recognition, and fusion applications. Image domain recognition techniques apply significant averaging to the underlying scattering physics such that unique feature information can be lost in the processing. Innovative prediction and analysis techniques that characterize complex target scattering features, background clutter features, and signature features that describe a target/background interaction in pre-image formation data domains are needed to allow the development of optimized processing algorithms and recognition techniques. The goal of this research is to develop optimal characterization of complex target and background scattering phenomenology for target detection and recognition algorithm development and apply these phenomenology representations in simulating and characterizing detection and algorithm performance. This topic solicits innovative solutions in the following areas: (1) Radar signature prediction techniques that characterize the scattering response of target in a pre-image formation data domain, (2) Radar clutter modeling techniques to support target in terrain scene signature predictions, (3) Innovative visualization, data analysis, and feature extraction techniques, (4) Computer-aided design (CAD) target modeling technologies to support signature prediction, and (5) Modeling and simulation methods for characterizing algorithm performance. Proposals that address one or a combination of the technology areas 1 through 5 will be considered.

Innovative physics-based phenomenology modeling techniques that support the prediction of radar observables from targets are needed. Signature prediction techniques for targets and clutter backgrounds should allow an imaging simulation of coherent sensed observables over a range of aspect angles such that sensor models can be applied as a post-processing step. Three-dimensional scattering centers extracted from complex image data are an abstract data characterization of complex target scattering. Signature prediction techniques should also support the development of innovative abstractions of target and background scattering phenomenology from pre-image formation data domains. Advanced analysis and feature extraction techniques that identify stable scattering features are also needed. Existing target geometry and material collection techniques for CAD modeling of complex targets are equipment and time intensive. Novel techniques that use hand-portable equipment to efficiently collect target geometry and material information on tactical targets are needed. Target information collection methods should consider methods of interfacing collected data with CAD build packages to support high fidelity target model builds for signature prediction applications. Higher level modeling and simulation techniques that use physics-based phenomenology representations are needed to accurately simulate algorithm performance. Modeling and simulation techniques should develop methods for modeling algorithm measures of performance based on physics-based phenomenology. Techniques for applying algorithm measures of performance derived using physics-based phenomenology in higher level modeling and simulation engagement models are also sought.

Phase I: Address at least one of the following: (1) Prototype physics-based modeling tool for a simple object or an object in terrain setting, (2) Prototype visualization or analysis tool to support feature extraction, (3) Develop a proof-of-concept target geometry/material collection system, (4) Develop a proof of concept physics-based measure of performance modeling and analysis technique, and (5) Develop proof-of-concept technique for using physics based phenomenology derived measures of performance in engagement modeling and simulation.

Phase II: Address at least one of the following: (1) Physics-based scene modeling tools for complex targets in terrain settings, (2) Develop a physics-based detection or recognition algorithm, (3) Develop a CAD geometry and material collection system, (4) Develop a physics-based measure of performance modeling and analysis tool, and (5) Develop a technique for using physics-based phenomenology derived measures of performance in engagement modeling and simulation.

Dual Use Commercialization Potential: Target and scene signature modeling techniques developed on this effort have application to large area site modeling for communication system design. Feature extraction and innovative algorithm concepts have application to advanced data analysis for consumer marketing analysis.

Related References:
1. Bhalla, R. H. Ling, J. Moore, D. J. Andersh, S. W. Lee, and J. Hughes, "3D Scattering Center Representation of Complex Targets Using the Shooting and Bouncing Ray Technique: A Review, " IEEE Antennas and Propagation Magazine, Vol. 40, No 5, October 1998, pp. 30 – 39.
2. Sullivan, D., D. Andersh, T. Courtney, N Buesing, and P. Jones, "Development of SAR Scene Modeling Tools for ATR Performance Evaluation," Algorithms for Synthetic Aperture Radar Imagery VI , SPIE, Vol. 3271, April 1999, pp. 572 – 581.

KEYWORDS: Electronic Protection (EP), Electronic Warfare, Electronic Counter-Countermeasures (ECCM)

AF03-218 TITLE: Model -Based Algorithms for Confident ATR Using 3d Data

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

Objective: Develop algorithms in a model-based framework that will confidently match observed 3d sensor data to target models.

Description: The Air Force Research Laboratory (AFRL) is actively pursuing algorithms for confident identification of targets using 3d data. Exploratory research is sought in the area of 3d ATR algorithms with the goal of improving the speed and confidence of target recognition, especially in the case where sensor noise (add-ins, drop-outs, location uncertainty) and target variabilities (articulations, configurations) preclude a trivial one-to-one match between predicted sensor data and observed sensor data. For point cloud data, for example, the combinatorics of the problem add up very quickly when the correspondence of the points is unknown, leading to a very computationally expensive process, especially in the case of a large target set. This topic solicits innovative solutions in the following areas: (1) algorithms for efficiently matching observed 3d data to predicted 3d data when correspondence is unknown; (2) algorithms for matching observed 3d data to 3d models directly without prediction; (3) features of 3d data that are suitable for matching; (4) methods to measure the confidence of a match; (5) algorithms for improving the performance of 3d ATR through multiple 3d sensor phenomenologies; (6) algorithms for efficient prediction of 3d data from 3d models for RF, laser, stereo-optical, or other sensor phenomenologies that will produce 3d data. Proposals that address one or a combination of technology areas one through seven will be considered.

An ATR system is only useful to the extent that the user has a high degree of confidence in its answers. 3d data seems to offer the promise of highly confident answers, but the most efficient ways of exploiting that data have not yet been fully explored. One of the problems with 2d data is the loss of information due to the projection of a 3d object onto a 2d plane. The availability of 3d data eliminates this problem, but new problems arise. What features will be useful for sensor phenomenologies that produce 3d data? How does one perform matching based on those features? How confident is the match? How should target articulation and obscuration be handled with 3d data? All these questions and more must be answered to begin to use 3d data to its full potential.

Phase I: Address the feasability of at least one of the following: (1) Algorithms for matching observed to predicted data. (2) Algorithms to match data to models without prediction. (3) 3d features that are suitable for matching. (4) Methods to measure the confidence of a 3d match. (5) Algorithms for improving 3d ATR performance using multiple 3d sensor phenomenologies. (6) Algorithms for efficient prediction of 3d data.

Phase II: Address at least one of the following: (1) Develop a prototype matching module for matching observed to predicted data. (2) Develop a prototype matching module to match data to models without prediction. (3) Develop a prototype feature extraction module. (4) Develop prototype confidence measures. (5) Develop a prototype fusion module combining at least two different 3d sensor phenomenologies. (6) Develop a prototype prediction module for 3d data.

Dual Use Commercialization Potential: Target recognition technology has wide application in the commercial market. Factory environments already use ATR technology for quality control, automated part sorting, automated production, etc. All of these applications stand to be enhanced by more confident 3d ATR technology. Any robotic vision system uses ATR technology, and their performance also will be benefited by more confident 3d ATR.

Related References:

1. Lao, S. et al, "3D template matching for pose invariant face recognition using 3D facial model built with isoluminance line based stereo vision." IEEE Proceedings, International Conference on Pattern Recognition. 3 Sept 2000. pp 911-916
2. Chao, Jinhui and Ishii, S. "Invariant recognition and segmentation of 3D object using Lie algebra models," IEEE International Conference on Image Processing, 24 Oct 1999. pp 550-554
3. Flynn, P. J. and Jain, A. K. "BONSAI: 3D object recognition using constrained search." IEEE Transactions on Pattern Analysis and Machine Intelligence. Vol 13, Iss 10. Oct 1991 pp 1066-1075
4. Weinshall, D. "Model-based invariants for 3D vision." IEEE Computer Society Conference on Computer Vision and Pattern Recognition. 15 June 1993. pp 695-696

5. Bergevin, R. and Hebert, M. "Generic object recognition: building coarse 3D descriptions from line drawings." Workshop on Interpretation of 3D Scenes. 27 Nov 1989. pp 68-74

KEYWORDS: Model-based Vision, 3d Data, Automatic Target Recognition, Computer Vision Matching, Confident ATR

AF03-219 TITLE: Missile Threat Warning Discrimination

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors, Electronics, Battlespace

Objective: Develop improved infrared discrimination methods and algorithms for detection, declaration, location, and identification of approaching threats by dedicated missile warning systems and multi-function sensors.detection, declaration, location, and identification of approaching threats by dedicated missile warning systems and multi-function sensors.

Description: Threat Warning systems are required to detect threat tactical missiles over wide fields of regard and initiate countermeasures in time to defeat the threat. The performance of threat warning systems is limited by their ability to isolate actual threats from background clutter. Current sensors use staring focal plane arrays to obtain images in one or more mid-infrared bands over a field of view of up to 4pi steradians at frame rates from 30 to 200 Hz. Generally, detection is accomplished using relatively simple high pass spatial filtering to suppress extended background clutter and applying constant false alarm rate thresholding techniques. The spectral and temporal characteristics of these detections are then analyzed to discriminate actual threats from non-threat detections and permit declaration of the presence of a threat with high probability and acceptably low false alarm rate. This analysis is limited by the capability to process the discrimination algorithms for a sufficient number of detections over a wide field of regard with a short response time. The requirement to detect smaller threats at maximum range has made this problem more difficult and is expected to require improved clutter rejection filtering techniques to permit lower detection thresholds and more complex discrimination algorithms which will, in turn, require more efficient data processing.

The goal of this program is to seek innovative sensor/processing concepts for the detection and declaration of threat missiles in clutter. It is expected that the concepts will involve spatial, spectral, temporal, or polarimetric techniques or a combination of these in the infrared, but alternative approaches showing comparable potential are acceptable. The emphasis is on the detection and declaration of tactical surface-to-air missiles at maximum range. Approaches should show potential of declaration times and false alarm rates consistent with requirements of flares or directed countermeasures. Techniques which provide passive ranging, time-to-go, and target ID are desirable, but of secondary importance. Impact on sensor/processor cost is a significant consideration.

Potential Solutions: The following paragraphs suggest some potential approaches to the warning sensor problem.
Spectral: Current multicolor staring sensors use filter wheels, two color arrays, or multiple optical paths to obtain images in two separate spectral bands. Future innovations envision the use of additional spectral bands for enhanced discrimination or tunable filtering to enable adaptive spectral processing. These developments will impact both sensor technology to obtain the required color data and algorithm development to permit timely processing.
Spatial/Temporal: The detection and declaration of sub-clutter threats requires effective suppression of spatial and temporal background clutter to the level of sensor noise and may require implementation of track before detect target enhancement techniques. Substantial work has been done in this area for reconnaissance sensors where sufficient time is available to permit relatively complex signal processing. For the warning sensor, where declaration times of the order of seconds are required, processing time becomes a driving issue. On-focal plane analogue processing may have the potential to solve this problem.

Phase I: Phase I is primarily analytical to show feasibility of the proposed approach.

Phase II: Phase II should result in laboratory demonstration hardware and/or software.

Phase III Dual Use Applications: These techniques will have application to image analysis and commercial aircraft sensors.

References: R.B. Sanderson, Infrared Missile Warning Sensors, National Aerospace Electronics Conference, Dayton, OH, 1996

KEYWORDS: Infrared, Warning, Discrimination, Backgrounds, Clutter.

AF03-220 TITLE: <u>Agile, Detecting and Discriminating, Infrared Electro-Optical Systems (ADDIOS)</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: The objective of this research is to determine the effectiveness of new imaging technologies, such as foveated vision, to accomplish missile warning and identification at tactically significant ranges.

Description: Current, staring, infrared imaging systems are limited to a centered field of view that might also have complicated electromechanical zoom mechanisms that are slow, have limited zoom capability as well as limitations on resolution. New technologies, such as advanced liquid crystals or holographic techniques, offer the promise of highly agile optical systems that allow wide fields of regard with nearly instantaneous switching of field of view (FOV). The ability to mimic foveal vision characteristics of the eye, achieving high resolution discrimination while rapidly switching within the FOV and providing surveillance of a large area, is needed for missile warning, missile cueing, administering countermeasures and targeting.

Phase I: Develop the theory and architecture for a near or mid-infrared, agile, optical system. Assess and document the capability of the system to switch a high resolution, instantaneous FOV to any location in a wide field of regard (FOR). Determine the resolution capability of the aperture, switching rates, optical distortion and other limitations. Demonstrate the potential for the system in a bench level test.

Phase II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over wide FOR and narrow FOV.

Dual Use Commercialization Potential: This technology can be used for a wide range of military and civilian security applications where wide area surveillance, high resolution and discrimination are needed. For example, a camera with a FOR of 120 degrees and an instantaneous staring FOV of 20 degrees would have sufficient resolution to discriminate faces or military targets. The system could dwell on target, or it could rapidly switch to another FOV allowing rapid targeting of multiple enemy targets.

Related References:
1. Massie, M. and P. McCarley, "Neuromorphic IR focal plane performs sensor fusion, on-plane local contrast enhancement, spatial and temporal filtering," Proc. SPIE, Vol. 1961 (1993).

2. McCarley, P., M. Massie, and C. Baxter, "NeuroSeek Dual Color Image Processing IRFPA," Proc. SPIE, Vol. 3360-02 (1998).

3. D. Stack, C. Kramer, T. McLoughlin, K. Sielski, G. Yang, C. Wrigley and B. Pain. "Target acquisition and tracking system based on a real-time reconfigurable, multiwindow CMOS image Sensor", Acquisition, Tracking and Pointing XIV, Michael K. Masten, Larry A. Stockum, Editors, Proceedings of SPIE Vol. 4025, pp. 170-181 (2000)

KEYWORDS: missile warning, missile identification, imaging, neuromorphic imaging

AF03-221 TITLE: Innovative Adaptive Processing Techniques for Wideband and Multi-Band Conformal Arrays

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: Study the issues associated with implementing multi-mission adaptive processing techniques with wideband and multi-band conformal array antennas and develop and demonstrate said techniques in a laboratory environment.

Description: In order to develop multi-mission sensors with the capability to detect difficult air and ground targets in the presence of severe clutter, ECM and RFI, the Air Force must develop a means to integrate conformal apertures into a variety of conventional airframes as well as future air vehicles including UAVs and mini-UAVs. However, many simplifying assumptions made by conventional adaptive processing approaches will be violated by conformal aperture designs. The extent to which conformal arrays will support accurately placed adaptive nulls with adequate null depth to achieve clutter cancellation requirements must be ascertained. The same may be said of Minimum Detectable Velocity (MDV) requirements. As such, the signal processing requirements associated with conformal arrays must be evaluated.

Phase I: During Phase I of this SBIR, a feasibility concept will be developed in response to projected Air Force applications of conformal array adaptive processing. This feasability concept will include a characterization of specific algorithms and their ability to achieve required levels of various pertinent metrics including subclutter visibility, minimum detectable velocity, and detection and false alarm probabilities. The required adaptive degrees of freedom (spatial and temporal) and sample support will also be included in this feasability study. Additionally, since conformal arrays are being considered as a means to reduce size, weight and power (SWAP), the feasability study must also address computational complexity so that SWAP reductions made possible by the conformal array are not increased by the associated adaptive processor. Thus, peak and sustained throughput and latency must be considered as part of this feasability study.

Phase II: During Phase II of this SBIR, at least one algorithm identified during Phase I will be prototyped and demonstrated. Atual conformal arrays or conformal array pattern data provided by the Government shall be used for this demonstration. The demonstration shall include an assessment against the performance metrics analyzed during Phase I.

Dual Use Commercialization Potential: The commercial potential is excellent for transitioning this technology into telecommunications (wireless) and navigation (GPS) systems utilizing conformal arrays mounted onto or integrated into air or ground vehicles.

Related References: none

KEYWORDS: Conformal Arrays, Wideband Arrays, Multi-band Arrays, Adaptive Signal Processing, Non-ideal Arrays.

AF03-222 TITLE: Feature Based Identification and Association

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: The objective of this effort is to develop innovative fusion algorithms that use feature information from disparate sensors to improve ground target identification and association.

Description: War fighters need an improved and consisten view of the battlefield so they can operate effectively. Achieving this capability cannot be accomplished reliably without fusion of information from multiple sensors. Sensors that gather Intelligence, Surveillance, and Reconnaissance (ISR) data are key contributors to forming this Common Operational Picture (COP). Current fusion approaches operate at the decision level. Each sensor provides an estimate of target identification. These estimates are then cmbined. This discards a tremendous amount of rich feature level sensor information that could be used for improved target identification. It may also violate independence assumptions by using similar features from multiple sensors. Currently, targert report association depends primarily on position information. This discards information that could be used to improve association. Commensurate features, which can improve association, like target size, is available from electro optical (EO), infra-red (IR) sensors, high range resolution (HRR) radar and synthetic aperture radar (SAR). Disparate features from these sensors such as shape, thermal signature and one or two dimensional location of radar scattering centers can be combined to improve identification. The goal of this effort is to develop innovative fusion algorithms for accumulating target identification and association evidence based on target features from different sensor types. Similar features available from dissimilar sensors that can aid in association and disparate features, which can be combined to aid in target classiciation, should be identified. Improvements in identification and association over decision level fusion will be evaluated.

Phase I: Identify features from several disparate sensor types which could be combined to aid in target classification or report association. Define a paradigm or algorithmic framework to fuse this information to provide target classification and report association. Demonstrate via engineering analysis or simulation improvements to classification and association for realistic scenarios.

Phase II: Expand the feature sets or sensor types considered in Phase I. Develop and demonstrate the algorithms defined in Phase I on simulated or real data. Evaluate performance improvements over traditional fusion and association techniques.

Dual Use Commercialization Potential: Military applications include surveillance of ground stationary and moving targets. This work is also applicable to landmine detection. Commercial applications include airborne and spaceborne mapping and charting. The technology developed under this effort can be directly extended to commercial distributed traffic monitoring for Intelligent Highway Systems and for law enforcement applications such as border surveilland. Medical applications include aiding diagnosis from imagery from dissimilar sensors such as X-ray, ultrasound, PET scans and CAT scans.

Related References:
1. Mathematical Techniques in Multisensor Data Fusion; Hall David L., Artech House, Norwood, MA, 1992.

2. A framework for multi-date multi-sensor image interpretation; Murni, A.; Jain, A.K.; Rais, J., Geoscience and Remote Sensing Symposium, 1996. IGARSS, 1996. 'Remote Sensing for a Sustainable Future.', International, VOL: 3, 1996, Page(s): 1851-1854, VOL 3.

3. Source diversity and feature-level fusion; Bedworth, M.D. Information, Decision and Control, 1999. IDC 99. Proceedings. 1999, Page(s): 597-602.

4. Automated melanoma recogntion; Ganster, H.; Pinz, P., Rohrer, R.; Wilding. E.; Binder, M.; Kittler, H., Medical Imaging, IEEE Transactions on, VOL: 20 Issue 3, March 2001, Page(s): 233-239.

KEYWORDS: Data Fusion, Target Classification, Vehicle Identification, Feature Extraction, Multiple Sensors

AF03-223 TITLE: <u>Sensor Suites for UAVs</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

Objective: Develop counter-terrorism and homeland defense small UAV capability involving advanced integrated RADAR/LADAR sensor suites incorporating compact millimeter wave device and ATR technologies suitable for Time Critical Targeting.

Description: The use of unmanned aerial vehicles (UAVs) has added a new dimension to Air Force war fighting capabilities to include innovative Time Critical Targeting sensor systems for combating terrorism and providing homeland defense. Small UAVs are attractive in that their lower unit cost should enable them to be more widespread than larger (Global Hawk or Predator-class) platforms. Existing sensor systems for wide area search, however, have been designed for larger platforms and ingenuity is required to develop sensors for small UAVs. It is desired that the sensor suite be able to perform wide area search for detection and nominal recognition of stationary and moving targets. Among possible components to achieve this are Synthetic Aperture Radar/Ground Moving Target Indication (SAR/GMTI), range-gated 3-D imaging laser (LADAR) sensing, andAutomatic Target Recognition. The result is a sensor system which can find targets and provide final, close in precise Combat ID and terminal guidance.

Phase I: Research is proposed for showing the feasibility of a sensor suite for small UAVs capable of allowing location and identification of Time Critical Targets. Because the small UAV is size, weight, and power (SWAP) constrained, there is a need to focus on the design of the individual sensors and their integrated operation. The first phase of the research will focus on identifying the system engineering, sensor performance tradeoffs, and conops development issues and to focus on issues related to assessing concept feasibility. No implementation or extensive algorithm development should be attempted in this phase. An important element of this phase is the investigation of what sensors are possible within the SWAP requirements, and how these sensors and related processing are integrated to complement one another and attain the desired target identification. The study will assess the feasibility or utility of integrating the coherent sensors across small-UAV platforms within an air delivered swarm concept or within a small-UAV platform.

Phase II: The small-UAV sensor system design will be integrated, further refined, and demonstrated within existing sensor system engineering modeling & simulation environment. The focus will be on refining the sensing and processing architecture and its performance for various sensor, environment, platform, and target parameters. To ensure the affordability of the sensor suite, research should be sure to incorporate a study of component cost & assembly as well as the approaches for interconnecting large component counts. This phase will develop or leverage existing time critical target scenarios appropriate for demonstrating and assessing the performance of integrated coherent sensor-equipped (ICS) small UAV swarms. A key part of this phase will be the research of appropriate algorithms for fast high confidence Combat ID sensing as well as the associated sensor performance management – sensor management at the sensor, platform and information levels.

Dual Use Commercialization Potential: Cost effective small UAVs with advanced sensing capabilities have multiple commercial applications. They can be used to perform “dull, dirty, or dangerous” tasks such as monitoring cattle fence lines or pipelines that run for miles and miles, EPA monitoring, airborne city patrol (monitoring traffic conditions or assisting in police pursuits), search and rescue, and drug enforcement.

Applications: Small UAV sensor system technology has immediate application to counter-terrorism and homeland defense in the area of wide area surveillance of vehicle and human surveillance in urban and remote environments using exploitation of range and Doppler information from both. Additional civilian applications exist in air traffic and drug traffic surveillance. The sensor technologies also apply to the design of intelligent highways.

Related References:
1. Gross D, Palomino A, Williams A, Westerkamp J, "Automatic Target Recognition of Time Critical Moving Targets Using 1D High Range Resolution (HRR) Radar", 1999 IEEE Radar Conference, 20-22 April 1999, Boston, MA
2. Williams R, Gross D, Westerkamp J, Palomino A, "Automatic Target Recognition of Time Critical Moving Targets using 1D High Range Resolution (HRR) Radar" IEEE AES Magazine April 2000 Orlando, FL
3. Gross D, Oppenheimer M, Kahler B, Keffaber B, Williams R, Preliminary Comparison of High Range Resolution Signatures of Moving and Stationary Ground Vehicles, SPIE AeroSense 2002 1-4 April 2002, Orlando, FL

KEYWORDS: Counter-terrorism, Homeland Defense, Surveillance, Identification, Radar, Ladar, Automatic Target Recognition, UAV, Uninhabited Aerial Vehicles

AF03-224 TITLE: <u>Innovative Sensors and Algorithms for detection and identification of time critical targets</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Develop and evaluate innovative sensor and algorithm concepts for targeting platforms for detection and identification of advanced time critical targets.

Description: Combat missions must now be accomplished in the face of significantly challenges such as; 1) enhanced surface to air missile defenses employing new engagement tactics by enemy air defenders such as frequent threat emitter shutdowns and shoot-and-scoot tactics; 2) targets under trees; and 3) moving targets. Innovative sensors and algorithms are required to improve detection range and identification of these time critical targets. Enhanced detection range and positive hostile ID may be obtained through the use of systems onboard the targeting platform and/or from off-board sources.

Phase I: The tracking and ID of moving targets continues to be a major technical challenge. A number of DARPA research programs have realized some initial successes under a limited range of operational conditions by employing High Range Resolution (HRR) radar modes. Phase I research will investigate the feasibility of using innovative processing to synthesize an Ultra High Range Resolution (UHRR) radar mode from existing SAR/GMTI sensor designs. If this is shown feasible, and effort remains, feasibility will be investigated of extending Space-Time Adaptive Processing (STAP) techniques to WideBand STAP (WB-STAP) for improved detection and identification of moving targets. This capability is desired as a sensing and processing front end to the Continuous Identification concept being developed at AFRL.

Phase II: In this second phase, the innovative UHRR WB-STAP sensor/algorithm system design from phase I will be demonstrated within existing sensor system engineering modeling & simulation environment. Algorithms will also be demonstrated using measured radar data to the extent that such data is available. The focus will be on refining the UHRR sensing and WB-STAP processing architecture and its detection and ID performance for various sensor, environment, platform, and target parameters. In the case of UHRR GMTI, tradeoff studies and analyses may be used to identify and understand significant parameters. The second goal is to develop concepts or procedures to optimize track/ID pictures developed by different tracking/ID schema on different radar platforms. Feasibility of the concepts or procedures needs to be established through simulation or engineering analysis. The method underlying the concept must be consistent with typical harsh multi-platform UHRR GMTI operating conditions such as tracking tens or hundreds of targets with reports lost due to obscuration and line-of-sight velocities that are less than minimum detectable velocities, while at the same time rejecting false alarms. In particular, projected computing and bandwidth requirements should not greatly exceed projected capabilities of onboard processing.

Dual Use Commercialization Potential: The principles of advanced innovative sensing and processing algorithms for detection and identification of time critical targets is immediately relevant and transitionable to commercial applications in sensing and processing for air traffic control, intelligent superhighways, sighted automation of factory assembly lines, and search and rescue. In these cases, it is expected that the technologies explored and refined under this SBIR topic will result in the ability to more intelligently and more quickly discriminate among aircraft, ground vehicles, machined parts, and downed or lost humans for improved commercial air-surface traffic, lower cost products, and saving of lives.

Related References:
1. Fennell, M., Wishner, R, “Battlefield Awareness Via Synergistic SAR and MTI Exploitation”, IEEE AES Systems Magazine, Feb. 1998.
2. Washburn, R., Chao, A., Castonon, D., Bertsekes, D., Malhotra, R., “Stochastic Dynamic Programming for Far-Sighted Sensor Management,” IRIS National Symosium on Sensor and Data Fusion, 1997.
3. Y. Bar-Shalom, Track ID Propagation in the Top M Hypothesis Tracking, ESP Lab TR-010531, Univ. of Connecticut, ECE Dept., Jun 5, 2001.
4.Gross D., Oppenheimer M, Kahler B, Keffaber B, Williams R, "Preliminary Comparison of High Range Resolution Signatures of Moving and Stationary Ground Vehicles", SPIE AeroSense 2002 1-4 April 2002 Orlando, FL
5. Schmitz J, Greenewald J, Williams R, "Model-Based Range Extent for Feature Aided Tracking", 2000 IEEE Radar Conference 8-12 May 2000 Alexandria, VA

KEYWORDS: Space Time Adaptive Processing, High Range Resolution Radar, GMTI, tracking, identification

AF03-227 TITLE: Precision Targeting

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: Detect, ID, and locate ground and air deep hide targets day/night from high altitude and space in time to support targeting.

Description: DESCRIPTION: Detection and identification of similar class military targets can be extremely difficult especially at extended ranges. The large number of deployment scenarios including backgrounds, geometry, and target states further complicate the discrimination process. This effort would investigate innovative Electo-Optic techniques or exploitation methods for target detection and identification. Of particular interest are approaches which capitalize on multiple target specific characteristics including but not limited to geometry (2-D and 3-D Imaging), plant/drive charateristics (thermal/vibration), material properties (passive/active multi-spectral imaging or intra-target polarization diverse imaging). For new approaches, methods to both generate and exploit the signatures should be presented. Priority will be given to approaches that develop and exploit new signature types, but innovative techniques to exploit existing ladar signature types such as 1-D, 2-D, and 3-D imaging as well as target vibration signatures will also be considered. Exploitation techniques may include automatic target recognition, signature enhancement & extraction, multi-signature fusion, or target reconstruction techniques. All techniques must have direct relavance to either the air-to-air or air-to-ground combat ID or surveillance missions.

Phase I: Characterize observable target attributes to be exploited and their implication on system design and utility. Design, implement and assess critical component technologies or algorithms to provide proof of concept for the approach. Determine approach utility and feasibility and perform tradeoff analysis for airborne applications with secondary consideration for space applications. Generate performance goals and preliminary design for the Phase II effort.

Phase II: Design, implement and demonstrate the advanced ladar technique and supporting hardware including transceiver (if required) and processing platform. Demonstrate the techniques through field trials of a breadboard/brassboard system. Perform utility analysis and develop sensor/algorithm specifications.

Dual Use Commercialization Potential: Military Application: Finalize System specification and develop brassboard sensor for field and flight test and demonstrations. Develop specifications for operation systems. Commercial Application: Ladar related technologies and the associated processing techniques have found wide application in the commercial markets. Potential commercial applications include surveying, time-of-flight imaging for medical diagnostics, and research, and space object imaging. Industrial/vision applications include process control, nondestructive testing, and surveillance/security.

KEYWORDS: laser radar, active imaging, laser vibrometry, polarization, 3-D Imaging, passive hyperspectral imaging, passive multispectral imaging, active multipectral imaging

AF03-228 TITLE: Integrated Sensing and Processing for Continuous Identification

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Joint Strike Fighter (JS)

Objective: To continuously detect, track, and identify time-critical targets whether moving or stationary using advanced integrated sensing and processing designs and algorithms.

Description: Achieving this capability in all weather conditions and at standoff ranges cannot be accomplished reliably without fusion of information from multiple sensors on multiple platforms. Current fusion approaches fuse information at the decision level, which unnecessarily discards a tremendous amount of rich object/feature-level sensor information that could be fused for improved target identification. Innovative fusion algorithms and fusion engines are needed for accumulating target identification evidence based on object-level target features from multiple sensors dispersed in time and space. This will be achieved by advanced integration of sensor design, sensor control, and ID algorithms. The result shall be "cumulative, continuous combat identification" of highly mobile surface targets through all phases of their movement history.

Phase I: Research is proposed for a feasibility study for a Continuous Identification concept focused on the integration of RF SAR/GMTI sensor technology, advanced space – time – frequency processing, and ID. The first phase of the research will focus on identifying the system engineering, sensor performance tradeoffs, and conops development issues and to focus on issues related to assessing concept feasibility. No implementation or extensive algorithm development should be attempted in this phase. An important element of this phase is the investigation of multisensor suites engineering, exploitation of multiple frequency bands to allow for fusion of off-board sensor data, advanced integrated sensing and processing to maximize Continuous ID performance. Existing stationary and moving target radar data sets will be used.

Phase II: In this second phase, a prototype of the Continuous ID sensor system design from phase I will be constructed within existing sensor system engineering modeling & simulation environment. The focus will be on demonstrating the utility of the sensing and processing architecture and its performance with one or two selections of sensor, environment, platform, and target parameters. Since on-board/off-board sensor data fusion is increasingly seen as a Continuous ID enabling technology, research will incorporate a study of multisensor performance control and resource management for fusing SAR and GMTI across multiple platforms to include ISR. A key part of this phase will be the research of appropriate algorithms for fast high confidence Combat ID RF SAR and GMTI sensing as well as the associated sensor performance management – sensor management at the sensor, platform and information levels.

Dual Use Commercialization Potential: Military target detection and recognition, drug enforcement, and potentially transportation system analysis.

Related References:
1. Fennell, M., Wishner, R, "Battlefield Awareness Via Synergistic SAR and MTI Exploitation", IEEE AES Systems Magazine, Feb. 1998.
2. Washburn, R., Chao, A., Castonon, D., Bertsekes, D., Malhotra, R., "Stochastic Dynamic Programming for Far-Sighted Sensor Management," IRIS National Symosium on Sensor and Data Fusion, 1997.
3. Y. Bar-Shalom, Track ID Propagation in the Top M Hypothesis Tracking, ESP Lab TR-010531, Univ. of Connecticut, ECE Dept., Jun 5, 2001.

KEYWORDS: Continuous Identification, Integrated Sensing and Processing, Sensor Control, SAR, GMTI.

AF03-229 TITLE: Synthetic Prediction Technologies for Infrared (IR) System Development

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Space (SP)

Objective: Develop innovative high fidelity IR and visible modeling technologies for targets in terrain settings.

Description: The Air Force is looking at emerging IR systems. Maturing these new sensor technologies will present challenges in data adequacy, modeling, and demonstrated performance. High fidelity physics-based IR and visible band modeling and simulation techniques for targets in terrain settings are needed to support system parameter trade studies. This topic solicits innovative solutions in the following technology areas: 1) IR and visible band target signature modeling. 2) Computer aided design (CAD) target modeling technologies to support IR and visible prediction techniques and 3) background modeling Techniques to support IR and visible target in terrain scene predictions. Proposals that address one or a combination of the technology areas 1 through 3 will be considered. Innovative physics-based phenomenology modeling techniques that will support the prediction of IR or visible band sensor observables from targets are needed. As thermal prediction techniques require significant computer run time, the development of near-real-time thermal signature prediction methods using innovative high fidelity thermal signature representations are needed. Novel techniques that use hand-portable equipment to efficiently collect target geometry and material information on tactical targets to support high fidelity multisensor target model builds are needed. Once a high fidelity target CAD geometry model is constructed, customizing a CAD model for IR and visible band predictions is man-intensive. Efficient CAD discretization, translator and surface healing methods that can be used to generate the input target geometry from a high fidelity geometric and material CAD model to support multisensor physics-based prediction methods are also sought. For example, a high-fidelity CAD geometry and material model built for radar predictions must be manually regridded to support thermal predictions. CAD tools that automate this process are needed to speed target insertion. Background modeling techniques that address IR or visible prediction for background terrain that includes tree regions are also sought. Target and background signature modeling techniques should allow the prediction of a sensed observable such that sensor-specific processing models can be applied as a post-processing step to allow sensor parameter trade studies.

Phase I: Solicitations should address at least one of the following: (1)Prototype IR or visible physics-based modeling technique for complex targets,(2)design or limited proof of concept of a target geometry and material collection system, (3)proof of concept CAD geometry healer/CAD translator, and (4) prototype IR or Visible modeling technique for terrain background regions.

Phase II: Solicitations should address at least one of the following: (1)Development of low IR or visible physics-based modeling technique for complex targets and/or targets in tree regions, (2)CAD geometry and material collection system, (3)CAD geometry healer/CAD translator, and (4) development of an IR or visible modeling technique for background terrain.

Dual Use Commercialization Potential: CAD data collection techniques and target and scene prediction techniques developed on this effort have applications to large-area site modeling for communication systems design.

Related References:
1. Johnson, Keith, Allen Curran, David Less, et. al, “MuSES: A New Heat and Signature Management Design Tool for Virtual Prototyping,” Proceedings of the Ninth Annual Ground Target Modeling and Validation Conference, Aug. 1998.

2. Lorenzo, Maximo, Eddie L. Jacobs, Joseph R. Moulton, Jesse Liu, “Optimized Mapping of Radiometric Quantities into OpenGL,” Proceedings of SPIE, Vol. 3694, p 173-182.

KEYWORDS: IR Signature Modeling, CAD Target Modeling, Visible Signature Modeling, IR Background Simulation, Scene Modeling, Tree Modeling

AF03-230 TITLE: GPS Civil Signal Validation Techniques

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Space (SP)

Objective: Design brassboard GPS receivers capable of using the new civilian L5 signal.

Description: As part of GPS modernization, the U.S. Government has committed to providing a new civil signal, designated L5, centered at 1176.45 MHz. The L5 carrier will be modulated by a spreading code with a longer sequence and a higher chipping rate than the C/A code. A new data modulation method will be used, including convolutional encoding. The formats of the Navigation Message will also change.

The L5 signal is in a band that includes many pulsed emitters, such as DME and IFF. GPS receivers designed to track the L5 signal will need to incorporate increased receiver sensitivity and pulse blanking.

The purpose of this research is to develop low cost, high fidelity brassboard receiver designs to assess the compliance of GPS civil signals to interface control documents and specifications. The receivers should also be able to assess any backward compatibility problems with existing signals. The receiver design must have the ability to track all satellites in view simultaneously, provide a precise navigation and timing output, and store all information for post-event processing.

A satellite broadcasting the L5 signal will not be available during this program. The contractor may need to simulate the L5 signal, or may be able to procure an existing signal simulator that can be modified to include L5.

Phase I: The contractor shall 1) Perform requirements analyses in Phase I to design a brassboard receiver that can be used for signal verification and validation. The receiver should be suitable for both laboratory and field testing. 2) Determine a suitable, cost effective method for generating simulated L5 signals, as well as GPS L1 and L2 signals. Consider means of simulating interference sources (e.g., DME). 3) Provide detailed documentation on the receiver design and signal simulation approach. 4) Provide a plan for receiver hardware and software development in Phase II. The plan should include a test and evaluation concept.

Phase II: The contractor shall 1) Finalize the Phase I receiver and signal simulator designs. 2) Produce a minimum of two brassboard GPS receivers capable of forming a navigation solution using any mixture of existing signals and the new L5 signal. 3) Develop or procure a signal simulator. 4) Develop a receiver performance verification plan. 5) Show by appropriate test and analysis that the receivers are capable of measuring L5 signal parameters with sufficient accuracy to support signal validation. 6) Deliver a report documenting the design and verification efforts. 7) Deliver a user's manual, written to contractor format, for the receiver.

Dual Use Commercialization Potential: Equipment delivered in Phase II can be used for both military and civil user equipment development programs.

Related References:
1. Van Dierendonck, A.J., Hegarty, C., Scales, W., and S. Ericson (2000) "Signal Specification for the Future GPS Civil Signal at L5", IAIN World Congress in association with the U.S. ION Annual Meeting, San Diego, California, June 26-28, 2000.

2. Spilker, J.J. and A.J. Van Dierendonck (1999) "Proposed New Civil GPS Signal at 1176.45 MHz", Proceedings of ION-GPS 99, September 14-17, 1999, Nashville TN.

3. Hegarty, C., and A.J. Van Dierendonck (1999) "Civil GPS/WAAS Signal Design and Interference Environment at 1176.45 MHz: Results of RTCA SC159 WG1 Activities", Proceedings of ION-GPS 99, September 14-17, 1999, Nashville TN.

4. "An Overview of the New 1176.45 MHz Civil Global Positioning System Signal (GPS L5)", US FAA Office of Spectrum Policy and Management, July 7, 1999
[Available at http://ntiacsd.ntia.doc.gov/gps/sharing/]

5. Van Dierendonck, A.J., and J.J. Spilker (1999) "Proposed Third Civil GPS Signal at 1176.45 MHz: In-Phase/Quadrature Codes at 10.23 MHz Chip Rate", Proceedings of The Institute of Navigation Annual Meeting, Cambridge, Massachusetts, June 1999.

KEYWORDS: GPS, Modernization, Civil Signal, Receiver, Test, Validation

AF03-233 TITLE: <u>Flow Control and Plasma Technology for Aerospace Vehicles</u>

TECHNOLOGY AREAS: Air Platform, Space Platforms

Objective: Develop flow control and plasma technologies to enhance aerospace vehicle configurations.

Description: Aerospace vehicles of the future will require increased performance to meet the threats of the future. Simultaneously, these vehicles will be required to be more affordable and supportable than current systems. To improve the performance of aerospace vehicles and make them more affordable, it is desirable to reduce or eliminate traditional aerodynamic control surfaces and other variable geometry, or use other nonintrusive techniques. For example, the use of flow control or plasma for altering local aerodynamic phenomena has been flourishing. With recent development of small devices to enable such control and demonstrations of stable plasma generations, these techniques show promise for drag reduction and control of shear layers, turbulence, and unwanted secondary flows. They also have potential for providing an apparent aerodynamic surface that can be tailored to different operating conditions (virtual shaping). Flow control areas of interest include integration of existing devices into aerospace vehicle concepts, new actuator designs with expanded frequency, amplitude, or inherent flexibility characteristics, development of rapid flow control design methods allowing designers to utilize the technologies in tradeoff studies, development of control systems for optimization of the device performance, and experimental validation of a potential device, or numerical simulation of the device to enhance understanding of the relevant flow physics. Plasma areas of interest include plasma generation methods, multidisciplinary design and analysis methods for system designs including plasma, energy requirements for plasma flow control on vehicle components, computational methods to predict physical phenomena in high-speed, high-temperature gases, and calculations and testing of electrohydrodynamic flow control with glow-discharge surface plasma. Innovations can be realized through the simultaneous consideration of multiple design disciplines as well as through highly efficient aerodynamic, aerothermodynamic, and integration concepts.

Phase I: Define the proposed concept, outline the basic principles, and establish the method of solution. Present an example of the advanced performance that will result from the technology. Determine the risk and extent of improvement over existing methods.

Phase II: Build a prototype application of the equipment or software. Demonstrate the advanced technology under actual engineering conditions or under simulated flight conditions.

Dual Use Commercialization Potential: Virtually every commercial market that deals with some aspect of flow control or plasma could stand to benefit from this technology. High efficiency commercial aircraft, quiet aircraft, more efficient aircraft engines, electronics cooling, enhanced turbine cooling, enhanced fans, compressors, quiet car interiors, are just some of the more obvious examples of the potential commercial applications. High-payoff military applications include flow-controlled compact inlets for miniature air vehicles, separation and acoustic control for integrating miniature weapons, low-cost, cruise drag reduction for both transport and combat aircraft and vehicles that provide access to space, and reduced runway requirement for transports.

Related References:

1. McMichael, J.M., "Progress and Prospects for Active Flow Control Using Microfabricated ElectroMechanical Systems (MEMS)," AIAA Paper 96-0306, January 1996.

2. Hwang, D.P., "A Proof of Concept Experiment for Reducing Skin Friction Using a Micro-Blowing Technique," AIAA Paper 97-0546, January 1997.

3. McManus, K.R. and Magill, J.C., “Airfoil Performance Enhancement Using Pulsed Jet Separation Control,” AIAA 97-1971, 4th AIAA Shear Flow Conference, Snowmass Village, CO, June 1997.

4. Gad-el-Hak, M., “Modern Developments in Flow Control,” Applied Mechanics Reviews, Vol. 49, pp. 365-379, 1996. (http://www.nd.edu/~gadelhak/Control.pdf).

5. Blyenburgh, P., “UAVs – Current Situation and Considerations for the Way Forward,” RTO EN-9 Development and Operation of UAVs for Military and Civil Applications, ISBN 92-837-1033-9, April 2000. (ADP010752 this document may be ordered from Public STINET http://stinet.dtic.mil/)

KEYWORDS: Flow Control, Plasma, Aerothermodynamics, Electrohydrodynamic, Configuration Integration

AF03-234 TITLE: Unified Computational Code for Rarefied and Continuum Flight Regimes

TECHNOLOGY AREAS: Space Platforms

Objective: Develop unified software product to computationally treat fluid flow in rarefied and continuum flight regimes.

Description: The recent resurgence of the Air Force interest in space access reveals an important need to treat flow problems in multiple flight regimes using a single fluid dynamic code. Such a code would be valuable to the vehicle designers who have the task of evaluating the vehicle aerodynamics in a variety of hypersonic flight regimes, rarefied, transitional and continuum. Such a capability is essential to aerodynamically optimize the vehicle shape in the stability analysis tradeoffs. At the present time, no such unified predictive capability exists. In evaluating the entire trajectory of vehicle aerodynamics, a measure of Knudsen number, the ratio of the mean free path to the characteristic length is used to decide on the computational approach that applies to that particular flight regime. Knudsen numbers can span anywhere from 0.001 to 100 for the choice of a consistent set of equations and solution algorithm. At the present time, computational fluid dynamics (CFD) codes, based on macroscopic equations, are used for predictions with varying degrees of accuracy in the continuum regime for low Knudsen numbers. CFD codes generally fail to predict in the transition regime to rarefied regime at the higher Knudsen numbers because their governing Navier-Stokes equations no longer apply. Direct Simulation Monte Carlo (DSMC) and collisionless DSMC codes based on the higher order Boltzmann equation are particle methods used for the rarefied regimes at higher Knudsen numbers but with relatively less validation because of the many technical challenges. There are also overlap regions at Knudsen numbers of 0.01 for the CFD/DSMC codes and 10 where both DSMC and collisionless DSMC analysis are required. The DSMC codes are known to fail in certain classes of problems, such as the internal flow problem of the space shuttle along its descending trajectory. If a macroscopic flow parameter such as the temperature is defined for the macroscopic set of equations, then a consistent definition need to be made in the microscopic particle method to allow proper comparisons. The unified code research effort involves technical challenges in choosing an appropriate set of equations and solution algorithms to solve them. Defining a proper criterion for the computer code to distinguish between the continuum and rarefied regimes is an active research area. Other challenges for the development of the unified code include numerical stability of the solution algorithm, fitting the problem within the available high performance computers, defining a consistent set of flow parameters and code validation to ensure that the proper physics is being simulated.

Phase I: Define appropriate governing equations and suitable algorithm(s) and present a unified code strategy. Present example(s) of the enhanced capabilities that will result from the proposed approach. Determine the risk and extent of improvement over existing approaches.

Phase II: Develop, demonstrate, and validate the proposed concept(s) for realistic configuration geometries and flow conditions that are of interest to the aerospace industry.

Dual Use Commercialization Potential: The resulting analysis tool could be used by both government and industry researchers to help design and analyze trans-atmospheric vehicles. The highest payoffs could be realized for the next generation Space Shuttle, the Air Force's Space Operations Vehicles & Long Range Strike Vehicles, and other planned commercial and military re-usable launch vehicles.

Related References:
1. Guidi, A., Chu, Q. P.; Mulder, J. A.; Buursink, J. "Implementation of a Re-entry CFD toolbox in the GESARED flight simulator," AIAA Atmospheric Flight Mechanics Conference and Exhibit, Montreal, Canada, Aug. 6-9, 2001, Aug 2001, AIAA Paper 2001-4314.

2. Glass, C. E., Moss, J. N. "Aerothermodynamic characteristics in the hypersonic continuum-rarefied transitional regime," AIAA Thermophysics Conference, 35th, Anaheim, CA, June 11-14, 2001, AIAA Paper 2001-2962. (http://techreports.larc.nasa.gov/ltrs/PDF/2001/aiaa/NASA-aiaa-2001-2962.pdf)

3. Staack, D., McDaniel, J. C., Glass, and C. E., Miller, C. "Experimental study of interacting rarefied and continuum flows" 35th AIAA Thermophysics Conference, Anaheim, CA, June 11-14, 2001, AIAA Paper 2001-2762.

4. Aristov, V. V., and Theremisin, F. G.," "The kinetic numerical method for rarefied and continuum gas flows" in Rarefied gas dynamics. Volume 1 (A86-42501 20-34). New York, Plenum Press, 1985, p. 269-276.

5. Glass, C. E., "Numerical Study of Rarefied Hypersonic Flow Interacting with a Continuum Jet" (Ph.D. dissertation), National Aeronautics and Space Administration, Hampton, VA Langley Research Center, November 2000.

KEYWORDS: Modeling and Simulation, Reentry Vehicles, Continuum Regime, Transitional Regime, Rarefied Regime, Unified Code Building

AF03-235 TITLE: Fly-By-Light (FBL) Technologies for Directed Energy Weapon Systems

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Weapons

Objective: Develop required fiber-optic cables, connectors and sensors for second generation fly-by-light technologies.

Description: Research has shown significant weight, volume and cost reductions are possible through application of emerging photonic technologies throughout the vehicle management system. This second-generation FBL architecture concept has centralized computing with distributed passive sensing and signaling. With photonics providing inherent electromagnetic interference (EMI) immunity; EMI shielding is required only at the vehicle management system computer (VMSC) box. While feasibility of the architecture concept has been shown, several technologies require a more complete understanding of various interactions and limitations so key components can be designed appropriately to function in the highly dynamic, multi-stress environment of aircraft operations. These technical challenges are briefly discussed below. One technical challenge is large numbers (e.g., hundreds) of fiber-optic cables will have to connect to the VMSC box, yet present aerospace fiber-optic connectors allow only up to 12 fibers per connector. Within the severe EMI environment of a Directed Energy Weapon System (DEWS), every connector into an electronics box is a path for EMI to enter and disrupt or destroy the electronics. Dense fiber optic connectors must be devised to solve the connector space problem on the faceplate of the VMSC box, while substantially reducing the number of EMI paths into the VMSC. Another technical challenge is the physical size of hundreds of individual fiber optic cables coming together into a wiring bundle. To facilitate fiber optic installation and maintenance in an aircraft, multi-fiber cables, breakout/fanout boxes and splices must be devised. Distributed sensing requires passive fiber optic sensors to operate in the harsh aircraft environment. The technical challenge for controlling motors and actuators are feasible current, voltage, linear position and rotary position sensors. For failure monitoring, temperature sensors are also of interest. Fault tolerance requirements and the flight critical application require sensors that provide nonincremental absolute measurements of the external physical parameter affecting the sensing fiber. Ideally, these sensors would have a common interface, use common electronics for signal processing and interfacing with the VMSC and be compatible with multimode wavelength division multiplexing.

Phase I: Investigate and demonstrate new and innovative technologies that can resolve one or more of the technical challenges discussed in this topic. This would be accomplished through appropriate research and then the design and analysis of the fiber-optic components. Modeling, simulation, or breadboard quality components are desirable to demonstrate feasibility.

Phase II: Develop prototype demonstration devices for the approach described and demonstrate a degree of commercial viability. This requires the development of hardware components consistent with form, fit, and function requirements for application to aerospace vehicle management systems. The hardware should also be capable of operating within the aircraft environment (i.e., temperature, vibration, g-shock, EMI, humidity, etc.).

Dual Use Commercialization Potential: This technology could lead to future military application in combat unmanned air vehicles, directed energy weapon systems, and other new aerospace vehicles. Potential commercial aviation applications include commercial and business jet flight control, commercial airline entertainment systems, and reusable launch vehicles. Potential nonaerospace applications include automotive drive-by-light, industrial automation, fiber-to-the-office/home computing, dense computing, and all-optical computing.

Related References:
1. Weaver, T.L. & Smith, R.H., “Photonic Vehicle Management”, 20th Digital Avionics Systems Conference, Daytona Beach, Fl, October 2001.

2. Sellers, Gregory J. and Roth, Richard F., “Multi-fiber optic connectors for aircraft applications”, SPIE Proceedings, Fly-By-Light: Technology Transfer, Orlando, Florida, Vol. 2467, pp. 87, April 1995.

3. Booth, B.L., Marchegiano, J.E., Chang, C.T., Furmanak, R.J., Graham, D.M., Wagner, R.G., “Polyguide™ Polymeric Technology for Optical Interconnect Circuits and Components” SPIE 1997. (http://www.opticalcrosslinks.com/pdf/photonics97.pdf).

KEYWORDS: Second Generation Fly-By-Light, Photonic Vehicle Management System, High Density Fiber Optic Connectors, Multifiber Cable Plant, Fiber-Optic Breakout/Fanout Box, Multifiber Splice, MultiMode Wavelength Division Multiplexing, Passive Photonic Sensors, Passive Fiber Optic Sensors

AF03-236 TITLE: Cooperative Decision and Control Algorithms with Information Flow Constraints

TECHNOLOGY AREAS: Information Systems

Objective: Develop analysis and synthesis tools for cooperative decision and control algorithms with information flow constraints.

Description: Cooperative decision and control algorithms for autonomous vehicle teams are of great interest, as these teams are envisioned one day to be capable of performing a number of key battlefield roles. Of particular interest to the Air Force is the cooperative control of autonomous, unmanned air vehicle teams for such missions as cooperative target search and classification and coordinated attack. Information flow constraints between autonomous vehicles performing cooperative tasks have not been sufficiently addressed. Vehicle, target, and threat information must pass between vehicles on network links having limited bandwidth. These data are subject to arbitrary delays as packets are lost and must be retransmitted. In addition, network connectivity may be limited because of geographical constraints or electronic countermeasures. Emerging cooperative decision and control strategies typically assume idealized information flow between all the vehicles. This unrealistic assumption could lead to suboptimal performance or even failure to complete a cooperative task. While the advantage of using teams of cooperating, autonomous vehicles is evident, the dependence on the flow of information leads to a need for considering what to do if information cannot be transmitted perfectly. The central question is how information flow constraints limit the performance of autonomous vehicle teams performing cooperative tasks. Network dynamics must be taken into account as part of the cooperative decision and control analysis and synthesis problem. Distributed optimization algorithms may be required for cooperative task assignment when information is incomplete. Tools are desired to enable analysis and synthesis of decision and control systems for cooperative control of autonomous vehicle teams. These tools must be able to provide guarantees of stability and robustness to changes in the information network topology and to optimize performance.

Phase I: Outline the basic principles of a cooperative decision and control algorithm for autonomous vehicle teams that explicitly accounts for information flow constraints, including limited bandwidth links, delays, and network topology limitations. Provide analysis and synthesis tools that quantify how information flow constraints limit autonomous vehicle teams’ performance, guarantee stability and robustness, and optimize performance. Choose a cooperative task to be performed and demonstrate the concept through a simplified simulation.

Phase II: Develop and expand the cooperative decision and control algorithm for autonomous vehicle teams and refine the analysis and synthesis tools. Demonstrate the concept on a detailed simulation.

Dual Use Commercialization Potential: The methods and tools developed under this effort will be applicable to a wide variety of commercial applications. These include autonomous automobiles for reduced highway congestion and autonomous aircraft operations for improved air traffic control throughput. These control techniques enable groups of autonomous vehicles to achieve performance not possible using manned vehicles.

Related References:

1. Phillip Chandler and Meir Pachter, "Hierarchical Control for Autonomous Teams," Proceedings of the 2001 AIAA Guidance, Navigation, and Control Conference, Montreal, Quebec, Canada, August, 2001.

2. Phillip Chandler, Meir Pachter, and Steven Rasmussen, "UAV Cooperative Control," Proceedings of the 2001 American Control Conference, Arlington, VA, June, 2001.

3. Phillip Chandler, Meir Pachter, Dharba Swaroop, Jeffery Fowler, Jason Howlett, Steven Rasmussen, Corey Schumacher, and Kendall Nygard, "Complexity in UAV Cooperative Control," Proceedings of the 2002 American Control Conference, Anchorage, Alaska, May, 2002.

4. J. Alexander Fax and Richard Murray, "Information Flow and Cooperative Control of Vehicle Formations," Proceedings of the 2002 IFAC World Congress, Barcelona, Spain, July, 2002.

5. Dimitris Hristu and Kristi Morgansen, "Limited communication control," Systems and Control Letters, Vol. 37, pp.193-205, 1999.

KEYWORDS: Autonomous Control, Cooperative Control, Multi-agent System, Decentralized Control, Information Flow, Bandwidth constraints, Distributed algorithms

AF03-237 TITLE: Future Technology for Aerospace Structures Technology

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Space Platforms

Objective: Develop structural technologies for conventional and high-speed manned and unmanned platforms.

Description: There are three primary research areas of interest. The first area is integrated structural design and technology. Within this area, research in innovative design concepts and analysis methods for three-dimensionally reinforced composites is needed to extend the use of composites in new systems or as substitutes into existing systems. In addition, multifunctional and adaptive structural concepts that provide for structural usage beyond the mere reaction of loads are needed for manned and unmanned systems. Finally, innovative design concepts, improved methodology and certification approaches are necessary for full utilization of composite bonds and mismatched material joining techniques. The next research area of interest is extreme environment structures. This area requires innovative design concepts for all-weather, durable integrated thermal structures, functionally graded advanced structures and thermal protection systems. These concepts are needed to achieve weight, cost, and operability goals for advanced systems such as the space operations vehicle or long range strike aircraft. Integrated structure/thermal management design concepts that are compatible with low observable technologies are sought for use in high temperature areas, such as airframe nozzles/exhaust washed decks. In both cases within extreme environments, life prediction techniques are required for both thermal/acoustic and thermal/mechanical load environments. The final area of interest is structural sustainment. Within structural sustainment life extension techniques, such as repair, structural integrity analysis methods, and vibration suppression, techniques are needed for reduced operations and maintenance costs, improved or maintained safety, and provision of increased system capability.

Phase I: Synthesize the proposed design concepts, outline analytical tool requirements for concept verification, and determine development risks and benefits.

Phase II: Refine design concepts with scale models and analysis tools. Validate design concepts using a building-block development approach, including elements, subcomponents, and eventual component-level verification testing. Validate analytical tools with experimental correlation. Demonstrate and quantify advanced technology function and performance.

Dual Use Commercialization Potential: A broad range of commercial applications exists in each research area. For example, multifunctional structurally integrated apertures and electronics can be applied to commercial aircraft, reducing the installation cost and weight by eliminating cutouts and reinforcing structure required to protect antenna apertures from flight. Adaptive structural concepts can be applied to both commercial and military aircraft to improve aerodynamic efficiency. Technologies related to extreme environments will be equally useful to both military and commercial space operations, and technologies related to structural sustainment should apply to both military and commercial transport industries.

Related References:

1. T.B. Irvine and C.A. Ginty, "Progressive Fracture of Fiber Composites," Journal of Composite Materials, Vol. 20, pp. 166-184, March 1986.

2. S.D. Fetter, "An Evaluation of Carbon/Silicon Carbide after NASP-Type Mission Cycling," Paper #121, 16th Annual Conference and Exposition on Composites and Advanced Ceramics, Cocoa Beach, Florida, January 12-15, 1992.

3. Lazarus, K.B., Saarmaa, E., and Agnes, G.S., "An Active Smart Material System for Buffet Load Alleviation," Proceedings from SPIE's 2nd Annual International Symposium on Smart Structures and Materials, Volume 2447, 1995, pp. 179-192.

KEYWORDS: Structures, Multifunctional Adaptive Structure, Analysis Methods, Thermal Structure, Unitized-Structure, Composites, Metallics, Sustainment

AF03-238 TITLE: Aerospace Structures

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Space Platforms

Objective: Develop innovative structural technologies for conventional and high-speed manned and unmanned platforms.

Description: Under this topic there are five areas of interest for which structural concepts, analytical modeling capabilities and certification techniques are required. The first area of interest is that of functionally graded structures for application to high speed and space operating vehicles as well as fleet aircraft. The requirements associated with future long-range strike vehicles and space operation vehicles are such that fully integrated structures are mandated. The requirements dictate that structures will be exposed to extremes in temperature, from cryogenic to re-entry temperatures, while carrying aerodynamic loads. The extremes in temperature lead to the need for functionally graded material properties and thus structures. In the area of fleet sustainment, functionally graded structures could be utilized to map the material properties to the load path for optimal weight and geometry distribution. The next area of interest is biomemetic structures. This area includes technologies such as those addressing self-repairing structures, self-replicating structures, self-diagnosing structures, and adapting structures (those that can determine damage and redirect structural load). Another area of interest is the field of nanostructures. Nanostructures includes within their broad umbrella the concept of making materials and products from the bottom -up, that is, building them up from atoms and molecules. This will lead to revolutions in the field of aerospace structures where these fabrication techniques will lead to structures requiring less material that can exactly match the structural requirements of the design. Multifunctional/adaptive structures is the next concept of interest. In the recent past, we have witnessed a paradigm shift in structural design that has eliminated the false barriers between vehicles design disciplines. This has enabled structures to become multifunctional. An example of this multifunctionality is the integration of subsystems into load bearing structures. Work in this area must continue to meet requirements of future unmanned aerospace vehicles. The final area of interest is that of simulation-based research and development (R&D), analytical certification, and multidisciplinary design. In this area issues such as procedures, tools and qualification, and technologies such as uncertainty analysis, probabilistic designs and software validation must be addressed.

Phase I: Synthesize the proposed design concepts, outline analytical tool requirements for concept verification, and determine development risks and benefits.

Phase II: Refine design concepts with scale models and analysis tools. Validate design concept using a building-block development approach including elements, subcomponents, and eventual component-level verification testing. Validate analytical tools with experimental correlation. Demonstrate and quantify advanced technology function and performance.

Dual Use Commercialization Potential: A broad range of commercial applications exists in each research area. For example, multifunctional structurally integrated apertures and electronics can be applied to commercial aircraft, reducing the installation cost and weight by eliminating cutouts and reinforcing structure required to protect antenna apertures from flight. Adaptive structural concepts can be applied to both commercial and military aircraft to improve aerodynamic efficiency. Technologies related to extreme environments will be equally useful to both military and commercial space operations. Technologies related to structural sustainment should apply to both military and commercial transport industries.

Related References:
1. Das, A., Ormbrek, G., and Obal, M., "Adaptive structures for spacecraft: a USAF perspective," SPIE Milestone Series MS, 2001, Vol. 167, pp. 30-42, SPIE- THE INTERNATIONAL SOCIETY FOR OPTICAL

2. Zhou, B. L., He, G. H., and Guo, J. D., "Bio-Inspired Study on the Structure and Process of Smart Materials and Structures," Solid Mechanics and Its Applications, 2001, Vol. 89, pp. 73-80.

3. Veley, Duane, Chris Pettit, and Richard Holzwarth, "Increased Reliance on Analysis for Certification of Aircraft Structures," Proceedings of the International Conference on Structural Safety and Reliability (ICOSSAR), Newport Beach CA, June 2001.

4. Whitesides, George M., and Love,Christopher J., "The Art of Building Small," Scientific American, September 2001.

KEYWORDS: Structural Concepts, Analytical Structures, Structural Certification, Functionally Graded Structures, Biomemetic Structures, Nanostructures, Multifunctional/Adaptive Structures

AF03-239 TITLE: <u>Small Unmanned Aerial Vehicles (UAVs) for Detection of Agents of Mass Destruction (SUDAMaD)</u>

TECHNOLOGY AREAS: Air Platform, Chemical/Bio Defense

OBJECTIVE: Develop extremely cheap disposable UAVs for detection, tracking, and tagging mass destruction agents.

DESCRIPTION: Recent bioterror attacks highlight the need to react to any chemical, biological or radioactive attack, quickly identifying the agent and its spread. The primary objective of this effort is to integrate novel air vehicle technologies with compact chemical sensors to provide real-time assessments of hazardous material releases from covert, cheap platforms.

The Air Force challenge is to detect agents and to, determine sources and extent. There are two general ways of sensing agents, remote and on-site. Remote sensing is currently under investigation, but weather and terrain conditions, as well as site location could render such remote sensing difficult. On-site sensing is possible with air delivered ground sensors; however, these cannot actively search for agents, only react when agents float by. Airborne systems could actively search for agents, identify sources, and map their spread. Such airborne systems need to be cheap, capable of aerial insertion, yet exhibit minimal impact to the logistical chain. They have to require minimal operator training, sparingly use communication bandwidth, and exhibit useful life. These airborne systems are envisioned to determine extents of attacks to the homeland, yet must also be able to identify agent research and development (R&D), manufacturing, and storage facilities in hostile countries. They also must be capable of sensing a broad range of agents, from chemical/biological to radioactive. It is a logical extension for such system to track other items, such as pollution, and light video cameras (< 6 g) have been developed which could also be used for intelligence collection, such as looking for victims within a cloud, or searching for caves. Therefore, operations should be automated through "plug and play" programming.

Although many approaches could be envisioned, recent advances in sensing and bio-inspired technologies might be useful to SUDAMaD systems. Biotechnology promises advances in sensor type and size reduction. Meanwhile, the Defense Advanced Research Projects Agency (DARPA) has demonstrated the vision of small UAV integration with its successful demonstrations of the Micro Air Vehicle (MAV) effort. The tantalizing hint of what could be a breakthrough system for sensing agents of mass destruction is within our grasp, what is needed is breakthrough integration to put all the functions together on one small air platform.

PHASE I: Conduct analysis and research to develop air vehicle system concepts which innovatively integrates the disparate functionality required for sensing WMD agents on small UAVs. By system concept we mean that we need to consider not just the air vehicle, but the control, power, and other technical parameters such that we can envision a system which can be released into an area where WMD agents could be, and it will search and find the agents, then report back. We assume that the small UAVs work in packs (coordinated), have decent range and loitering capability, are small such that covert sensing can be accomplished, and are very inexpensive. We also assume that once they are released the human operator has as little interaction as possible. Develop a baseline mission to evaluate technology alternatives. Perform initial trade studies showing the suitability of the UAV system alternatives, evaluating practicality while determining the number of UAVs required for a mission based on technology used. Develop initial concept(s) of UAV group insertion method(s). Choose the "best" system design to bring forward to Phase II. Show how other agencies besides the USAF could use this and for which roles.

PHASE II: Leveraging results of Phase I, extend to a group of UAVs having some initial capability of sensing agents of mass destruction in a collaborative fashion by evaluating their capability in a virtual world. Construct a UAV using Phase I "best" system and demonstrate, via a test using an appropriate sensor, the UAVs capability to find a surrogate agent cloud, locate the source, and track dispersion. Using simulation, extrapolate real world UAV test to a group of UAVs accomplishing the same mission. Complete a study on applicability and integration of various sensor payloads. Determine appropriate communication system. Determine system reliability. Complete commercialization plan.

PHASE III DUAL USE APPLICATIONS: SUDAMaDs can be used wherever an aerial concentration exists that needs to be mapped. Whether it is a nuclear agent release from a power plant, toxic vapor from a chemical plant, or pesticides from farming, the resulting cloud can be tracked. The only difference is in the particular sensor installed. Local agencies, Federal Emergency Management Agency (FEMA), law enforcement, Environmental Protection Agency (EPA), etc.-- could all be customers for the technology. SUDAMaDs could track drug processing; search for natural gas leaks, or search for lost hikers provided the appropriate sensor is installed in the vehicles.

References:
1. B. Clough, 'Swarms? So What Are The Implications And How Do We Handle Them?,' Presentation at AUVSI Unmannd Systems 2002 Symposium, Orlando, FL. July 2002.
2. D. Frelinger, et al., "Proliferated Autonomous Weapons – An Example Of Cooperative Behavior." Rand Corp. Documented Briefing. From Project Air Force, Available from Rand Corp. website, (1997).
3. M. Tilden, "Coordinated Covert Detector Ecologies," Symposium on Micro Robot Design and Control, ASME, International Mechanical Engineering Congress and Exposition, 16-21 November 1997.
4. E. Bonabeau, M. Dorigo, and G. Theraulaz, Swarm Intelligence: From Natural to Artificial Systems. Oxford University Press Inc, New York, NY (ISBM 0-19-513158-4) 1999.
5. J. McMichael and M. Francis, "Micro Air Vehicles – Toward a New Dimension in Flight," from the DARPA/TTO website www.darpa.mil/tto, 1997.
6. "OAV Capability Statement, BAE Systems". BAE System. From DARPA/TTO Web Site www.darpa.mil/tto 2001.
7. R. Arkin, T. Collins, Y. Endo, "Tactical Mobile Robot Mission Specification and Execution," on-line publication available from www.cc.gatech.edu/aimosaic/robot-lab/mrl-online-publications.html, 1999.
8. Barry Brian Werger and Maja J Mataric, "Robotic 'Food' Chains: Externalization of State and Program for Minimal-Agent Foraging" in Proceedings, From Animals to Animats 4, Fourth International Conference on Simulation of Adaptive Behavior (SAB-96), Pattie Maes, Maja Mataric, Jean-Arcady Meyer, Jordan Pollack, and Stewart W. Wilson, eds, MIT Press/Bradford Books, 625-634, 1996.

9. V.M. Shalaev, Nonlinear Optics of Random Media: Fractal Composites and Metal-Dielectric Films, Springer, STMP v.158, Berlin, 2000.
10. V.M. Shalaev, "Nonlinear Optics of Random Media: Fractal Composites and Metal Dielectric Films," Springer Verlag, Berlin, 1999; N.
11. N. Lepeshkin, W. Kim, V. P. Safonov, J. G. Zhu, R. L. Armstrong, C. W. White, R. A. Zhur, and V. M. Shalaev, "Optical Nonlinearities of Metal-Dielectric Composites," Journ. of Nonl. Optical Physics and Materials, 8, 191 (1999).
12. W. Kim. V. P. Drachev, V. A. Podolskiy, V. M. Shalaev, and R. L. Armstrong, "Raman and Hyper-Raman Spectroscopy at Low Light Intensity in Fractal-Microcavity Composites," submitted for publication.
13. W. Kim, V. P. Safonov, V. M. Shalaev, and R. L. Armstrong, "Fractals in Microcavities: Giant Coupled Multiplicative Enhancement of Optical Responses," Phys. Rev. Lett., 82, 4811 (1999).

KEYWORDS: Swarming, Biomimetics, Swarm Intelligence, Distributed Control, Intelligent Agents, Multi-Agent System, Decentralized Control, Cooperative Control, Swarms, Distributed Autonomous Systems, Biological Warfare, Biological Agent Detection, Chemical Warfare, Chemical Agent Detection, Chemical Detection, Swarming, Hazardous Material Detection

AF03-242 TITLE: Variable Pressure High Speed Test Track

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: AAC (XPTT)

Objective: Design and demonstrate a very large volume variable pressure chamber. The concept would lay the groundwork for a variable pressure high-speed test track capability.

Description: Sled tracks are used to test DoD weapon systems at various locations around the U.S. Sled test are conducted at speeds up 10,000 feet per second. Current sled test hardware is plagued with adverse aerodynamic effects, the most damaging being aero-thermal heating of sled test structures. Aerodynamic drag also is a key determinate of maximum obtainable sled test velocities. By enclosing a sled track with a variable pressure chamber most-to-all adverse aerodynamic effects could be eliminated. In addition, a variable pressure chamber might provide a versatile capability of simulating hypersonic flight through the atmosphere using large-scale (or full scale) test articles propelled by rocket motors, on test track rails. This capability would be invaluable for air-breathing propulsion system development and testing.

This system might consist of portable segments of "pressure vessel" (perhaps like a segment of a large culvert) that can be attached together to form a very long pressure vessel. The unique and risky requirement here is that this pressure vessel total length will most likely be thousands of feet. In addition, development of fast acting valves or some other technique to allow a sled to enter and exit the pressure vessel, while the sled is traveling up to 10,000 feet per second, without allowing changes in the pressure within the vessel must be developed. Diaphragms inside the pressure vessel could maintain different pressures in different parts of the vessel to simulate flight from lower to higher, or higher to lower altitudes.

Phase I: Develop overall variable pressure test track concept. The effort should address preliminary system design. This feasibility assessment should include technical assessment as well as cost and schedule estimates.

Phase II: Develop a prototype system that demonstrates the variable pressure test track concept. Conduct testing to prove feasibility of the concept.

Phase III DUAL USE APPLICATIONS: Follow-on activities are expected to be aggressively pursued by the offeror, namely in seeking opportunities to leverage the findings of the study and demonstration to help develop high-speed ground transportation systems. Much thought and some investment has been expended in researching highs speed ground transportation systems. Some of these concepts include an enclosed, low-pressure chamber to reduce or eliminate adverse effects of aerodynamics. The use of an variable pressure chamber would greatly reduce energy costs of high-speed ground transportation systems.

Related References:
1. Bosmajian, Neal AIAA 2000-0160, "Development of a Hypersonic Ground Test Facility-A National Asset Utilizing Maglev", AIAA Paper 2000.

2. Stix, Gary, "Maglev Racing to Oblivion? ", Scientific American Article, Issue 1097, may be found at: http//www.sciam.com/1097issue/1097s stix_maglev.html-8k

3. Hicks, John W., "Flight Testing of Airbreathing Hypersonic Vehicles", NASA Technical Memorandum 4524, October 1993.

KEYWORDS: hypersonics, test tracks, high speed ground transportation, fast acting valves, air- breathing propulsion systems, aero-thermal protective materials

AF03-243 TITLE: Test Range Mobile Relay Platform

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: AAC (XPTT)

Objective: Provide a high-flyer relay for Telemetry, Communications and Global Positioning System (GPS) systems.

Description: The current land based test ranges do not offer realistic test scenarios to many of the large footprint weapons currently under development. In order to provide a more realistic test environment, test ranges will be heavily utilized to provide the required footprints for these weapons of the future. Currently, test ranges lacks much of the basic infrastructure to support testing. Since the infrastructure cannot be permanently installed over the entire test range, a mobile test infrastructure must be provided that can travel with the various test profiles. The test profiles could be a hundred miles or more out over water, which presents a challenge for the land based TM and GPS sensor packages. In order to bridge the gap between the test area and the land-based sensors, a high altitude platform is required to relay various types of information (TM, GPS, VHF, UHF, etc.).

Phase I: Determine the feasibility of using an airborne platform for high altitude relay of data, in support of flight testing over a water range. The initial research should determine if sufficient airborne technologies exist to support testing over water ranges, especially when this testing can be at a great distance from the shoreline. The airborne platform should be able to carry a sufficient electronics payload to enable telemetry and communications relays at distances in excess of 100 nautical miles from shore. The airborne platform must be able to carry sufficient fuel to get to its loiter position, remain there for up to 8 hours and return to base. Since multiple missions may need to be supported simultaneously, the ability to deploy multiple airborne platforms is a requirement. Likewise, the airborne platform must have a remote control system sophisticated enough to support multiple vehicles acting in unison to support data relay for multiple test items. This research should explore the use of conventional fixed wing aircraft, but it should not be limited to using this approach. New innovations in airborne technologies; capable of supporting the high altitude relay requirement, is one of the primary goals of this research. The airborne platform must be small in size and highly transportable to multiple launch sites, which will be located at various points along the Gulf of Mexico coastline. Since it is reasonable to assume the simultaneous deployment of 5, 10 or more airborne platforms, the airborne platform must be low cost to build and maintain. Also, the control and relay electronics must be low cost to keep the overall cost of this system at a minimum. Finally, it will be a significant technical challenge to design a small, reusable, low cost and airborne electronics platform with sufficient range and loiter time to meet the challenging requirements for testing over a water range. The technical risk is further compounded by the fact that this system must be able to network multiple airborne platforms together to support multiple tests with multiple test items. Such a capability would not only be an asset to testing over the Gulf of Mexico, but testing over any large water range.

Phase II: Design and build a prototype system that performs to the innovative criteria developed in Phase I. Document, demonstrate, and provide the results and method of operation to include: control system, flight profiles, maximum payload, propulsion, maintenance, et cetera.

Phase III (Dual Use Commercialization Potential): If the Phase I and Phase II efforts are successful, then the ultimate goal will be to procure and take delivery of a number of these airborne relay platforms for support of testing over the Gulf of Mexico.

This concept could be expanded to include other military locations, which could deploy these vehicles for support of missions that are deep into the test range waters. Additionally, this technology could be utilized at other DoD installations in support of testing over various remote land and water ranges. A cost effective and reusable airborne platform can have many applications for both military and commercial. The primary military use for the platform will be data relay, but it could also be used for reconnaissance, if outfitted with the proper electronics.

As mentioned earlier, another military application for this vehicle is reconnaissance. If the vehicle is small, stealthy, unmanned and/or low noise, it could easily penetrate enemy territory to collect RF and video data. If the vehicle is relatively cheap to build, multiple vehicles can be deployed to examine the battlefield and it will limit the impact if one of the vehicles is lost during a mission.

On the commercial side, the airborne platform could be used in search and rescue, by providing an "eye in the sky". Assuming the vehicle is relatively cheap to build, multiple vehicles can be deployed by Search and Rescue and/or Police to provide an aerial viewpoint. Larger search areas could be covered with large numbers of this cost effective vehicle, rather than deploying cost inefficient helicopters and light aircraft. Since the commercial communications industry is expanding exponentially, there are many communications applications for a high-flyer relay. If the airborne platform can loiter for extended periods of time, then a semi-permanent communications relay could be established over a mountainous area or large body of water. The airborne platform could also provide a cheap method of research over the Gulf of Mexico or other locations, by providing the ability to count various aquatic (or land) species from an altitude.

Related References: Gerken, Louis, "UAV – Unmanned Aerial Vehicle: RPV – Remotely Piloted Vehicle," American Scientific Corporation, 1991.

KEYWORDS: Relay, Electronics, Telemetry, Airborne

AF03-244 TITLE: Generic, Multi-Platform, Real-Time Data Monitor

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: AAC (XPTT)

Objective: Support precision weapons development and testing using real-time data monitoring that is neither project nor platform dependent.

Description: Current methods of monitoring and collecting test data are both project and platform dependent. Each weapon system being tested dictates a different type and set of parameters to monitor, collect and analyze. Testing methods often involve different computing platforms. This requires that a unique set of data monitoring and collecting tools be developed for each project supported. The Guided Weapons Evaluations Facility (GWEF) has a current need for data monitoring capability to support Hardware-In-The-Loop testing of various weapons systems. The resulting capability should support hosting on multiple platforms, such as PC Windows, Linux, Silicon Graphics, and VMS/Alpha. It should support multiple interfaces, such as RS-232, Ethernet, IEEE parallel, shared memory (SCRAMnet), and various file systems. It should be able to collect and display the test data in real-time, variable sampling times and have a means of external, precision time synchronization. The system should be able to display the data in a variety of formats, including textual in both hexadecimal and engineering units and graphical, using combinations of line graphs, bar graphs and virtual instruments. Software in the data monitoring system should take into account cross-platform differences in data storages and formats (i.e., big endian, little endian, various floating formats, etc.). The software should be easy to reconfigure and operate. Changing from one test project to another should be as simple as changing a configuration file or operations parameter file. This configuration file should be easily produced using user-friendly, graphical user interfaces (GUI). The software should have the ability to perform post-test display and data reduction from archived data and convert the data to a variety of formats compatible with other programs (i.e., Microsoft Excel, Matlab, etc.). The software should be user-friendly and easy to operate. The turnaround time for monitoring and collecting test data between successive weapons test runs should be less than a minute. Currently there are no software products of this type in existence. This innovative software product would save several man months of programming and development for each weapons test setup. A common data monitoring and collection tool would shorten the overall training time and increase the base of possible users. With such a software tool, there would be little or no additional training required to transition from one project to another. If configuration and operation are made simple enough, lower grade, non-technical personal could be utilized to collect data and perform post-test data reduction.

Phase I: Develop proof of concept design usable on several computing platforms (i.e., PC Windows, Linux, Silicon Graphics, and VMS/Alpha).

Phase II: Develop a working prototype and demonstrate the prototype's operation on at least two different platforms. In the event the contractor chooses to conduct the demonstration at the Guided Weapons Evaluations Facility, they can conduct the demonstration using the facilities available at the GWEF at no additional cost to the SBIR contract.

Dual Use Commercialization Potential: Develop a complete software product with formal documentation and user's guide and demonstrate its operation using several different platforms and weapon systems. This software has an immediate need at the GWEF and if successfully developed, will be used extensively. This software could be used by anyone who uses software simulations that produces data. Successful development of this software could lend itself applicable to other areas of data collection and monitoring such as collection and display of test range data. It could replace or augment weapons test equipment at depot and/or field level. It could also be applied to other types of data than weapons test data (i.e., avionics, communications, flight systems/subsystems, etc.). This software could also have broad applications in the commercial marketplace, where real-time data monitoring is required (i.e., airports, stock-markets, weather services, etc.).

Related References:

1. Charles L. Phillips and H. Troy Nagle, Jr., Digital Control System Analysis and Design, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1984

2. Huibert Kwakernaak and Raphael Sivan, Modern Signals and Systems, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1991

3. William Stallings, Data and Computer Communications, Prentice-Hall, Inc., Upper Saddle River, N. J., 2000

KEYWORDS: Generic, Multi-platform, Real-Time, Data monitoring, Data collection

AF03-245 TITLE: Modular Narrow Band RF Generator

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: AAC (XPTT)

Objective: Develop ruggedized, field deployable high power narrow band radiofrequency (RF) generator capable of simulating threat sources in the frequency interval 100 MHz to 3000 MHz.

Description: Current narrow band RF generators are generally configured to produce a single frequency and other frequencies can only be obtained by constructing a completely new device. The technical challenge here will be to develop a modular RF generating system that will permit high power (several hundred megawats) of discrete narrow band output over a large frequency band 100 MHz to 3000 MHz. This generator would then be used to simulate threat narrow band sources designed to attack/defeat electronics of Blue systems. Blue systems would include both

US Military weapons systems, e.g., military aircraft, command and control networks, air operations centers, etc, and US commercial infrastructure, e.g., banking networks, industrial control networks, utilities control networks, etc.

Phase I: Phase I will require innovative research on available or completely new narrow band source types, amplification schema, and antennae designed with an eye toward developing a highly reliable field deployable modular RF generation system capable of producing required output. Further, this phase will provide recommendations to the sponsor as to which source, amplification and antenna designs lend themselves to modularization into a single adaptable RF generating system.

Phase II: Phase II will require the development, integration, and field demonstration of a prototype modular RF generator to prove reliability, maintainability, adaptability to required frequency outputs and power, and rugged design.

Dual Use Commercialization Potential: As the terrorist threat grows, it is highly likely that US infrastructure components including any driven by computer networks may be exposed to high power RF devices (eg, off the shelf high power radars)to defeat the computer controls of such components. Examples may include electrical power switching stations, banking networks, natural gas and water supply networks, etc. Availability of such modular high power RF generators should be directly applicable to T&E of US infrastructure targets against this evolving threat. If Phase II proves successful and funding is available, anticipate production of 2 to 4 additional units for use at other US MRTFB ranges.

Related References:

1. Army Science and Technology Master Plan 10(d,e).

2. DOE DDV-92-0014, Survey of U.S. RF Sources and Simulation Facilities, OSD HPM Implementation Panel, April 1992.

3. DTIC SUBJECT: 19-12 Directed-Energy Weapons; 14-02 Test Facilities, Equipment and Methods.

4. AFRL/DE Technical Report, DC-TR-0328.111-1, Matrix Low Frequency Design Report.

KEYWORDS: Radiofrequency, High Power Microwave, susceptibility, military platforms, test and evaluation, weapons, terrorist RF threats.

AF03-246 TITLE: Miniature/Sub-miniature Infrared (IR) Camera

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: AAC (XPTT)

Objective: Develop a miniature, mid-wave, high resolution, airworthy FPA camera.

Description: The 46th Test Wing employs calibrated, radiometric mid-wave infrared (IR) cameras in support of today's war fighter. Some uses for these cameras are

· Evaluation of new weapon systems
· Development of IR missile and target models
· Tracking camera

These cameras are used on platforms that operate at altitudes from sea level to 50,000 feet. Due to limited payload capability of the platforms and the relatively large footprint of the existing sensors, real estate has become a limiting factor in determining mission requirements. Commercially available, miniature sized IR camera systems are limited to sensitivity in the short and long IR wavelengths – .9 to 1.7 and 8 to 12 microns. Since these units use un-cooled detector technology, the overall profile and size of the camera is dependent upon the detector and it's associated electronics. Because the vast majority of IR guided weapon systems are not responsive in these wavelengths and use cooled detector technology, the 46th TW desires a miniature/sub-miniature radiometric camera system sensitive in the mid-wave IR region (1.5 to 5.0 microns) of the spectrum. Detector cooling techniques and their associated footprint with selected detectors is research that is required before such a camera could be commercially available.

Phase I: 1. Investigate technologies applicable to the design of a mid-wave, miniaturized, FPA camera.
2. Develop functional block diagrams of the different camera system designs.
3. Perform a cost and capabilities analysis.
4. Select final design and feasibility concept based upon performance/cost/size criteria

Phase II: 1. Develop a prototype FPA camera capable of demonstrating all key performance features.
2. Validate and demonstrate the prototype system meets the camera performance specifications agreed upon during Phase I.

Phase III: Commercialization of the prototype has dual-use potential for the follwoing applications: DoD air-to-air IR signature modeling, IR countermeasures evaluation and automated/man-in-the-loop tracking systems where camera size is a constraint.
The technology developed under this topic can be utilized in commercial applications such as mobile automotive applications, search and rescue, air to ground environmental/ecological monitoring and power/transformer line monitoring.

Related References:
1. Flaherty, Richard, et al. "Infrared Imaging Systems Analysis," DTIC ADA363982, 1988.

2. Hudson, Richard, "Infrared System Engineering", Wiley and Sons, 1969.

KEYWORDS: Focal Plane Array, IR Camera, IR Sensor, Mid-wave, Radiometric

AF03-247 TITLE: <u>Longwave Infrared Focal Plane Array for Imaging Fourier Transform Spectroscopy</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: AAC (XPTT)

Objective: To develop a high speed, high spatial resolution, simultaneous integration, long-wave infrared focal plane array suitable for use in imaging Fourier Transform Spectroscopy applications.

Description: Modern smart weapon systems rely on spatial and spectral signatures to acquire, track, engage, and destroy targets. Development and test of these smart weapons requires the signature characteristics of targets be accurately known. The Department of Defense is currently developing instrumentation which utilizes imaging Fourier Transform Spectroscopy (FTS) to collect these target signatures. A shortfall has been identified in focal plane array technology required to build FTS signature collection instrumentation in the longwave infrared. Performance goals of a focal plane array suitable for this FTS application include 8 to 12 micrometer waveband, 320 by 256 or greater spatial resolution, with simultaneous integration, and readout rates of 400 frames per second or greater.

Phase I: Phase I of this effort will be to research high risk, high payoff, innovative processes associated with fabrication of a focal plane array imager which reaches performance goals. The analysis, preliminary design, and experimental investigation of intermediate fabrication steps should be performed and documented during Phase I.

Phase II: During Phase II, the final design and assembly of a functional prototype imager will be completed. Phase II should demonstrate that the prototype meets the desired performance necessary for use in an FTS instrument.

Dual Use Commercialization Potential: Remote sensing of chemical and particulate matter in the atmosphere is currently performed utilizing non-imaging Fourier Transform Spectroscopy. Dual use applications include:

pollution monitoring of green house and other gases, detection of plant nutrient stress in precision agriculture, and chemical and biological warfare agent detection. The availability of an imaging focal plane array imager, as developed under this SBIR, holds the potential to transform these sciences by adding spatial information. A Phase III follow on would integrate the developed focal plane array imager into a Fourier Transform Spectrometer product designed specifically for dual use markets.

Related References:

1. Anderson, R., et al. "Military Utility of Multispectral and Hyperspectal Sensors", IRIA State of the Art Reports, DTIC 246890-3-F, November 1994.

2. Parrent, George B.; Thompson, Brian J.; "Rev. ed. of: Physical Optics Notebook: Tutorials in Fourier Optics", Optical Engineering Press/SPIE, 1989.

3. "Proceedings: Fifth Workshop on Infrared Emission by FTIR", ABB Bomem, February 2000.

KEYWORDS: Focal Plane Array (FPA), Fourier Transform Spectroscopy (FTS), Fourier Transform Infrared (FTIR), Infrared (IR) Imager, Remote Sensing

AF03-248 TITLE: Survivability of Aircraft to Terrorist Missile Threats

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: AAC (XPTT)

Objective: Develop a low-cost infrared decoy capable of reducing aircraft vulnerability to shoulder-launched missile threats.

Description: The shoulder-launched infrared (IR) Man Portable Air Defense System (MANPADS) threat is a highly effective weapon that is proliferated worldwide. Highly mobile and difficult to detect, the missile offers little opportunity for warning and subsequent evasion before impact. Impacts often prove lethal. Examples include 1) the Afghan mujahedeen killing of 269 Soviet aircraft using 340 MANPADS missiles, 2) Desert Storm evidence that IR missiles produced 56% of the kills, and 3) commercial aircraft incidents demonstrating a 70% probability of kill given a MANPADS hit. Such high kill ratios are unacceptable and require immediate solutions. Aircraft survivability is achieved through a combination of susceptibility reduction (hit avoidance) and vulnerability reduction (hit survival). While avoiding the hit is preferred, doing so is not always possible. Recognizing this problem, the Air Force Special Operations and Air Mobility Commands list "Limited Effective Countermeasures: Special Operations Forces Aircraft are Vulnerable to Detection and Destruction" and "Combat Operations Vulnerability" as warfighter deficiencies. The FAA and Homeland Defense Offices have similarly recognized MANPADS as a critical threat to commercial aircraft. Emerging susceptibility reduction systems, while promising, come at a cost and weight that precludes immediate installation on all aircraft. Military legacy and commercial aircraft go largely unprotected. A simple decoy system may assist the war on terrorism. The proposed task involves identifying and developing an innovative, low-cost, MANPADS hit-point biasing concept designed to guide missiles to least-vulnerable locations on selected aircraft. Hit-point biasing, in the form of an IR decoy, will provide a low-cost and near-term survivability solution for otherwise-unprotected legacy and commercial aircraft.

Phase I: Identify innovative low-weight and cost-effective hit-point biasing concepts that offer the potential of altering missile impact locations to least-vulnerable regions on otherwise-unprotected military and commercial aircraft. Use general aircraft design knowledge to perform cursory investigations of proposed hit-point biasing concepts, their effectiveness for a variety of MANPADS threats, technical feasibility of implementation, and minimization of cost/weight. Develop one or more brass board IR decoy devices. Perform fly-out/endgame and vulnerability simulations to evaluate Probability of Hit Given a Launch and Probability of Kill metrics for success.

Phase II: Select one or more promising hit-point biasing concepts (investigated in Phase I) for advanced development. Selected concepts must offer at least a 50 percent improvement to aircraft survivability (in terms of reduced Probability of Kill) at a cost per system of less than $50K. Perform MANPADS hardware-in-the-loop fly-out/endgame simulations (and potentially, ground-based testing) of a prototype IR decoy system. Identify successes and deficiencies of each decoy concept.

Dual Use Commercialization Potential: Select a finalist decoy concept from the Phase II and advance the design for direct application to legacy military and commercial aircraft. Dual use applications are supported through FAA interest in low cost/weight solutions for commercial aircraft survivability. The proposed IR decoy concept is ideal in that it will be sufficiently low-tech for immediate (and unclassified) transition to a wide variety of commercial aircraft. Adaptation of IR decoys to commercial aircraft will provide an added measure of homeland defense and terrorist protection.

Related References:
1. Langer, K., et al., "MANPADS Threat to Aircraft: Executive Summary", SURVIAC TR 99-014, JTCG/AS 99-V-003, February 2000.

2. U.S. Patent 6,267,039 "Aircraft Missile-Hit Survivability Using Infrared Lamp and Sacrificial Support Structure."

KEYWORDS: aircraft, survivability, vulnerability reduction, MANPADS, shoulder-launched missile, low cost, infrared, IR, decoy

AF03-251 TITLE: <u>High-Response Total Temperature Distortion Measurement</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: Arnold Engineering Development Center (AEDC)

Objective: Measure time-variant total temperature distortion at the entrance of a turbine engine during direct-connect ground tests.

Description: The simulation of aircraft hot-gas ingestion in turbine engine ground tests, using temperature distortion generators, requires the measurement of steady-state and time-variant distributions in total temperature. The measurements are needed to characterize the distortion produced by the generator for correlation with turbine engine response. The temperature rise rates of interest with respect to engine response are on the order of 8000 deg R per second with total rises of approximately 300 deg R. To characterize the spatial variation in total temperature, high-response measurements will be obtained at up to 48 locations distributed over the annular area upstream of the turbine engine face in a direct-connect test. Applications may range from subscale tests of the aircraft inlet to full-scale tests of the turbine engine. If total temperature probes are used, blockage considerations will demand probe diameters under 1/16 in. for the subscale applications (assuming a duct diameter of 6 in.). Although the probe diameter may increase for full-scale applications (with the larger ducts), the goal is to minimize aerodynamic blockage.

Phase I: A feasibility assessment identifying technologies that may be applied to high-response total temperature measurements.

Phase II: Develop a prototype of a total pressure measurement system applicable to subscale research experiments in test annulii ranging in diameter from 6 to 16-in. The temperature rise rates of interest with respect to engine response are on the order of 8000 deg R per second with total rises of approximately 300 deg R.

Dual Use Commercialization Potential: Test methodologies for ground evaluation of airframe-propulsion integration, experimental basis for development of turbine engine computational models.

Related References:
1. Rudey and Antl, "The Effect of Inlet Temperature Distortion on the Performance of a Turbo-Fan Engine Compressor System." AIAA-70-625

2. Braithwaite and Graber, "The Effect of Inlet Temperature and Pressure Distortion on Turbojet Performance." AIAA-73-1326

3. Graber and Braithwaite, "Summary of Recent Investigations of Inlet Flow Distortion Effects on Engine Stability." AIAA-74-236

4. Braithwaite, Soeder, "Combined Pressure and temperature Distortion Effects on Internal Flow of a Turbofan Engine." AIAA-79-1309.

5. Society of Automotive Engineers, "A Current Assessment of the Inlet/Engine Temperature Distortion Problem." Aerospace Resource Document ARD50015.

KEYWORDS: High Response Temperature

AF03-252 TITLE: Miniature Absolute Pressure Transducer

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Arnold Engineering Development Center (AEDC)

Objective: To produce a low cost pressure transducer for hypersonic for very low-pressure levels to be containing a volume less than .5 cubic inches.

Description: Cost savings to wind tunnel customers would typically range from $15K to $50K per test installation. Also, usual pressure settling delays would be minimized allowing increased tunnel productivity that would result in more savings. Force and moment data would be of higher quality due less tubing and cable bridging the force transducers. Pressure transducer replacement would take a fraction of the current time. Finally, more test article measurements could be made due to the space savings from both smaller transducer size and fewer pressure tubes and instrument leads. Typical flight performance studies using hypervelocity wind tunnel test articles involve the measurement of very low pressures at elevated temperatures. Current technology allows for the measurement of these pressures, but many sacrifices must be made in order to achieve a reasonable level of accuracy. Normal pressure installations require extensive preparation, lengthy tunnel installation, in-situ pressure calibrations and system verification. A solution to rapidly install, measure and transmit flight performance data is highly desired. This solution should connect to existing analog data acquisition systems, require than 0.5 cubic inch in volume per transducer and accurately measure pressure within 0.0025 PSIA in a hypersonic test environment (range 0 to 5 PSIA, temperature 50 to 250 Fahrenheit).

Phase I: Analytically and experimentally determine the feasibility of developing a miniature pressure transducer functioning to an acceptable level of accuracy while exposed to the desired ranges of pressure and temperature. A proof of concept demonstration is required.

Phase II: Produce a prototype pressure transducer that is capable of accurately measuring base pressures distributed on a model in a hypersonic wind tunnel.

Dual Use Commercialization Potential: In addition to test and evaluation customers, these transducers could be adapted for installing in rotating equipment, automotive, aircraft and hand-held altimeters.

Related References:
1. Porro, A. Robert "Pressure Probe Designs for Dynamic Pressure Measurements in a Supersonic Flow Field." 19th International Congress on Instrumentation in Aerospace Simulation Facilities (ICIASF 2001) Cleveland, OH 27-30 Aug. 2001.

2. Selim, Raouf. "Interface Properties of MEMS Sensors on Airfoil." 1998 NASA-HU American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program.

3. "High-Temperature Pressure Sensors Made From Silicon Carbide." LEW-16772, NASA Tech Briefs, January 2000.

KEYWORDS: pressure transducers, elevated temperature

AF03-253 TITLE: Computational Toolkit for Generating Missile Signature Databases

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: Arnold Engineering Development Center (AEDC)

Objective: The objective of this effort is to complement limited threat missile measurements using high fidelity, physics-based computational simulations in order to fill measurement voids and provide a comprehensive threat signature database that can be utilized for sensor evaluations in hardware-in-loop-facilities as well as for sensor assessment and feasibility studies.

Description: In order to evaluate detection sensors, the radiometric signature of threat missiles must be known a priori throughout the missile's trajectory envelope at aspect angle orientations that represent probable engagement scenarios. The acquisition of signature measurements during flight tests of high missiles including all wavelength bands, flight envelops, and aspect angles orientations is not currently feasible. In most cases measurements are obtained during sea level static test conditions only, and include observations at very limited aspect angles. This effort will focus on developing innovative computational tools for characterizing tactical and strategic missile signatures in terms of the dominant physics occurring in rocket thrust chambers and exhaust plumes, including chemical kinetic combustion, gas dynamic wave propagation and Mach disc formation, two-phase gas/particle non-equilibrium, exhaust plume mixing and afterburning kinetic chemistry, and radiative transfer mechanisms in the infrared and ultraviolet spectral regions. This effort seeks the development of accurate and reliable computational tools to evaluate and characterize multi-spectral IR and UV signature data of missile plumes in terms of their relevant physical/chemical and radiative characteristics. Innovative approaches that utilize available signature measurements, complemented with state-of-the-art standard computational modeling techniques are sought to identify the phenomena impacting radiative signatures as a function of the threat missiles flight altitude, Mach number, and viewing geometry.

Phase I: Demonstrate feasibility to expand on existing techniques for characterizing missile signatures using both measurements and calculated results from physics-based numerical models.

Phase II: Develop a full characterization toolkit employing the concept(s) derived from the Phase I effort. This tool must be robust and efficient and contain characterization parameters for a full array of missile systems. Demonstrate the proof of concept on several missile systems, covering a wide range of propellant compositions and flight conditions.

Dual Use Commercialization Potential: This technology will have utility for a wide array of signature applications, such as tactical and strategic scene generation and hardware in the loop simulations.

Related References:
1. Dash, S.M. and Pergament,H.S., ''A Computational System for the Analysis of Mixing/Chemical/Shock Processes in Supersonic Internal and Exhaust Plume Flowfields.''AIAA Paper No. 80-1255, Hartford, Conn., June 1980.

2. Dietz, Kathryn., etal, "The Advanced Missile Signature Center Support of the OSD Joint Tactical Missile Signature JTF," Dietz, K.L., Gamble, R.A., McGregor, W.K., Bradley, D., Brown, R. (Col. USAF), 2nd NATO IRIS Symposium, Westminster, London, England, 25-28 June 1996 (UNCLASSIFIED)

3. Simmons,M.A. "The Integration of CFD Modeling and Simulation into Plume Measurement Programs", AIAA 99-2255, Presented at the 35th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Los Angeles, California, June 20-24, 1999.

4. Lankford, D.W., etal. "A Detailed Numerical Simulation of a Liquid-Propellant Rocket Engine Ground Test Experiment", Presented at the 28th AIAA Joint Propulsion Conference, Nashville, Tennessee, July 1992.

KEYWORDS: Missile Radiometric Signatures, Detection Sensors, Plume Physics, hardware-in-the loop simulations

AF03-254 TITLE: Computational Fluid Dynamics (CFD)-Based Test Facility Design System for Reliable and Controlled Flow Quality

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes

ACQUISITION PROGRAM: Arnold Engineering Development Center (AEDC)

Objective: Develop a validated Computational Fluid Dynamics based design system to provide reliable, on-demand delivery of specified flow quality to large-scale, engine component and system testing wind-tunnel test facilities.

Description: Air-breathing and rocket engine manufacturers and customers rely on thrust and other performance measurements performed at government Aeropropulsion test facilities for final engine certification. The Air Force Engine Test Facility, Propulsion Wind Tunnel and Von Karman Facilities represent among the most heavily used ground-based test facilities in the world. Various test cells are up to 48 feet in diameter, and 85 feet long. Special purpose tunnels are unique in being able to simulate high altitude (near-vacuum) conditions.

To simulate conditions over the entire flight envelope and for off-design parameters, special purpose equipment is used to provide specified temperature gradients and other inlet flow distortions to the engine intake ducts. To ensure that required flow conditions are being generated, it is proposed that a design-oriented CFD code be validated using detailed facility and engine inlet condition data, and enhanced as a rapid-turnaround tool to assist in real-time adjustment of flow conditions to match testing requirements. Major hardware and flow path elements in the validation include characterization of inlet screens, heaters, distortion devices, turbulence generators, Venturi meters, foreign-object detection screens, and miscellaneous ducting systems. Major CFD technologies to be incorporated include parallel computing for Windows, Unix and Linux operating systems, unstructured grid capability with direct links to CAD design packages, and unsteady Navier-Stokes modeling capability for high Reynolds number, large length scale, subsonic and transonic flow conditions.

The resulting code, installed and optimized for the Air Force High Speed Computing network, will provide design and test engineers an effective and reliable tool capable of characterizing and ensuring delivery of specific inlet test conditions for each measurement point.

Phase I: Demonstrate feasibility of a CFD based computational tool to assist in real-time adjustment of flow conditions to match testing requirements. Demonstrate an approach to validate and calibrate the code using detailed facility and engine inlet condition data.

Phase II: Demonstrate the Critical components of the rapid-turnaround tool to assist in real-time adjustment of flow conditions to match testing requirements. Major hardware and flow path elements in the validation will include characterization of inlet screens, heaters, distortion devices, turbulence generators, Venturi meters, foreign-object detection screens, and miscellaneous ducting systems.

Dual Use Commercialization Potential: The CFD code and methodology will be applicable for both commercial as well as military wind tunnel and engine test cell analyses of flow quality.

Related References:
1. M.D. McClure, "AEDC Test Facility CFD Modeling", AIAA Paper 2000-0745, Reno, NV., January 2000. [2 more required]

2. Salas, A. O., and Townsend, J. C., “Framework requirement for MDO Application Development” AIAA 98-4740, 1998.

3. Meakin, R.L., Computations of the Unsteady Flow About a Generic Wing/Pylon/Finned-Store Configuration, AIAA Paper AIAA-92-4568, Presented at the AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, NC, Aug. 1992.

KEYWORDS: Test Facility, Flow Quality

AF03-255 TITLE: Expandable, Intelligent Switchgear Corona Monitoring

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Arnold Engineering Development Center (AEDC)

Objective: Develop a health monitoring system for power distribution switchgear and motor windings using corona detection as an operating principle.

Description: The condition of electrical switchgear is a concern as it affects lifetime and reliability issues for testing. The insulation on motor windings is also a concern. A system capable of continually monitoring corona discharge in medium and high voltage switch gear and breakers as well as in motor windings and providing a fault diagnosis to plant personnel based on corona signature, frequency, level, and other factors is desired. The system must be able to characterize common or recurring patterns as given faults, and be able to provide a diagnosis of faults based upon both industry and local experience with these devices. The system must have an expandable database where recurring faults will can be added and subsequently diagnosed.

Phase I: A feasibility demonstration of the software or critical sensor technology for diagnosing faults will be performed.

Phase II: Develop a health monitoring system for power distribution switchgear and motor windings using corona detection as an operating principle. A prototype system should include all the necessary sensors and software for the partial discharge monitoring of switchgear and motor windings. The capabilities of the system must be demonstrated in the field by assessing the health of actual switchgear and motor windings.

Dual Use Commercialization Potential: All heavy industry uses high voltage equipment and associated switches, motors, and breakers. A system that will allow the diagnosis of common faults in such devices without the need to hire consultants will save money on monitoring and maintenance, and therefore has a large commercial appeal.

Related References:
1. "Proceedings AAAI-87 Sixth National Conference on Artificial Intelligence, July 13-17, 1987 / sponsored by the American Association for Artificial Intelligence", [Menlo Park, CA] : The Association ; Los Altos, CA, Distributed by Morgan Kaufmann Publishers, c1987

2. A. Golubev, I. Blokhintsev, G. Paoletti, and J. Modrowski, "On-Line Partial Discharge Applications to MV Metalclad Switchgear," EIC/EMCW Conference, Cincinnati, OH, October 16-18, 2001.

3. Y. Han and H. Song, "Use of Self-organizing Map for Interpretation of PD On-line Test Data," EIC/EMCW Conference, Cincinnati, OH, October 16-18, 2001.

4. Weber H. and Seeberger R., "Field Measurements of Partial Discharges in potential transformers," IEEE Electrical Insulation Magazine, Vol. 2, No. 5, 1986, pages 34-38 .

KEYWORDS: Corona, Health Monitoring, Expert System, Neural Net, Circuit Breaker, Switch Gear

AF03-256 TITLE: Momentum Accommodation Coefficient Measurement Device

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Arnold Engineering Development Center (AEDC)

Objective: Develop a system that can directly measure the surface momentum accommodation coefficient of satellite materials under various conditions of surface temperature and surface treatments.

Description: The measurement of surface momentum accommodation coefficients is necessary to predict the lift and drag of satellites. Momentum accommodation coefficients have typically been inferred from measurements of the velocity distribution of the incident and reflected molecules in a molecular beam facility. This is a difficult measurement since the velocity and flux of reflected molecules must be determined in all directions. It is therefore desirable to determine the momentum accommodation coefficient by directly measuring the force applied to a surface immersed in a well-characterized beam or free jet.

It is well known that the momentum accommodation coefficient is sensitive to the condition of the surface. Clean, crystalline surfaces exhibit much different accommodation coefficients than rough "engineering" surfaces. Also, the accommodation coefficient for a particular surface may be altered by exposure to UV or thermal radiation or the exhaust of chemical, thermal, or electric thrusters. The potential for sputtering the surface is also of concern with electric thrusters. Therefore, the device must be able to generate a variety of surface conditions. Incident beam energy and composition should approximate orbital conditions, i.e. atomic oxygen at 5-8 km/sec.

A high productivity, low cost technique for directly measuring the momentum accommodation coefficient for typical satellite surfaces is required. The system should provide surface temperatures in the range of 100 – 400 K. The uncertainty of the measured accommodation coefficient should be less than 5%.

Phase I: Analytically and experimentally investigate the feasibility of developing a system that can measure the momentum accommodation coefficient by direct force measurements. A proof of concept demonstration is required.

Phase II: Develop a prototype system that is capable of measuring the momentum accommodation coefficient of typical satellite surface materials at a variety of surface conditions.

Dual Use Commercialization Potential: In addition to companies involved in low density testing and material characterization, satellite and solar cell manufacturers and integrators could use this device to determine the aerodynamic characteristics of proposed configurations

Related References:

1. F. G. Collins and E. C. Knox, "Parameters of Nocilla Gas/Surface Interaction Model from Measured Accommodation Coefficients," AIAA J., Vol. 32, No. 4, 1994, pp. 765-773.

2. S. R. Cook and M. A. Hoffbauer, "Measurements of Momentum Transfer Coefficients for H2, N2, CO and CO2 Incident Upon Spacecraft Surfaces," LA-UR-97-2898, 1997.

3. E.M. Gaposchkin, "Calculation of Satellite Drag Coefficients," NASA Technical Report AD-A285118, Massachusetts Institute of Technology, 1994.

4. S. R. Cook, "Molecular Beam Measurements of Absolute Momentum Accommodation of Spacecraft Surfaces Using a Specialized Torsion Balance," Ph.D. Dissertation, The University of Texas at Austin, 1995.

5. R. H. Krech, M. J. Gauthier, and G. Caledonia, "High Velocity Atomic Oxygen/Surface Accommodation," AIAA Paper 91-1339, 1991.

KEYWORDS: accommodation coefficients, molecular scattering, cross-sections

AF03-257 TITLE: Non-intrusive Optical Smoke Meter for Turbine Engines

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Arnold Engineering Development Center (AEDC)

Objective: Develop a non-intrusive smoke meter for turbine engines that provides a rapid, low-cost method for measuring the smoke number as defined by SAE ARP 1179B.

Description: Smoke is defined as small gas-borne solid particles, including but not limited to black carbonaceous material from the burning of fuel, which in sufficient concentration create visible opacity. The smoke number, a dimensionless term quantifying smoke emissions, increases with smoke density and is rated on a scale from 0- 100. The ARP describes the test equipment and procedures for the measurement of optical smoke emissions from aircraft gas turbine engines. The current method requires the use of an extractive probe, sample lines, flow rate measurement apparatus, smoke collection apparatus and an optical reflectometer filtered with a green tristimulus filter with peak transmission at 545 nm and full with half maximum (FWHM) of 100 nm. Extractive probes and complex gas sampling equipment is very expensive to acquire and current test methodology is expensive to operate. What is needed is a simple optical technique that can be correlated with the ARP extractive method for Smoke Number measurement.

Phase I: Laboratory test demonstration of the optical method to be correlated with Aerospace Recommended Practice (ARP) 1179B methodology.

Phase II: Develop a non-intrusive optical smoke which is both rugged and simple to operate. During demonstration testing it must be shown that the prototype optical smoke meter correlates well with a standard SAE smoke meter as defined in SAE ARP 1179B.

Phase III Dual Use Applications: The cost of acquiring, maintaining and operating current turbine engine smoke measurement equipment is very high. If a low cost easy to operate optical system could be developed it would have customers in both aero and non-aero engine (stationary source) markets.

Related References:
1. SAE, Aerospace Recommended Practice (ARP) 1179C, "Aircraft Gas Turbine Engine Exhaust Smoke Measurement", August 1997, SAE, Inc, 400 Commonwealth Drive, Warrendale, PA. 15096;
2. Jalbert and Zaccardi, "Improved Methodology for Turbine Engine Emissions Measurement", IGTI Paper No. GT-2002-303606, June 2002,
3. SAE Aerospace Recommended Practice J1157, "Measurement Procedure for Evaluation of Full-Flow, Light-Extinction Smokemeter Performance", August 1976, SAE, Inc, 400 Commonwealth Drive, Warrendale, PA. 15096
4. Publication available from International Civil Aviation Organization (ICAO) ICAO Annex 16 Volume 2 Aircraft Emission Measurements

KEYWORDS: Smoke number, optical smoke meter, emissions

AF03-260 TITLE: Multiband Multimode Programmable Telemetry Transmitter

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Flight Test Center (FTC)

Objective: Research and develop a user programmable telemetry transmitter capable of tunable operation from 1.4 to 2.4 GHz and able to support multiple bandwidth efficient modes of operation.

Description: Telemetry transmitters have evolved over time from somewhat large fixed frequency transmitters to smaller tunable transmitters designed to cover a specific telemetry band. The next logical step in this evolution would be the development of tunable multiband transmitters. Doing so would increase the operational flexibility of flight test conducted at Major Range Test Facility Bases (MRTFBs) by allowing schedulers to move flight-test mission into available spectrum with greater ease. This would be a huge benefit in today's environment of "doing more with less - spectrum." Likewise evolving are the modulation modes supported by these transmitters. The traditional telemetry transmitter has been Frequency Modulated (FM). Digital telemetry data, commonly referred to as Pulse Code Modulation (PCM), is fed into an FM transmitter and the deviation is set to a specified level based on the data rate. PCM/FM modulation is sometimes referred to as Continuous Phase Frequency Shift Keying (CPFSK). Through the efforts of the Advanced Range Telemetry (ARTM) Program, advanced modulation schemes are being developed that are bandwidth efficient and yet still perform in a manner similar to CPFSK with respect to parameters such as data quality, multipath performance and nonlinear amplification. Examples of new modulation formats compatible with aeronautical telemetry applications include FQPSK, SOQPSK and Multi-h CPM. The combination of frequency agility and spectrum efficiency offered through this SBIR effort will provide the telemetry community with tremendous flexibility to manage our ever-decreasing spectrum resources. The goal of this SBIR will be to develop a programmable multiband multimode telemetry transmitter meeting the following general requirements: individual component size not to exceed 2.5"W x 3.5"D x 1"H (excluding connectors); output power of 10 Watts; input data rates from 100 Kbps to 10 Mbps in the CPFSK mode and 1 Mbps to 20 Mbps in the FQPSK-B, SOQPSK-A and Multi-h CPM modes; must operate successfully over the altitude, temperature, shock and vibration environment of a typical fighter aircraft and/or missile system; must meet the Inter-Range Instrumentation Group (IRIG) Standards and Test Methods referenced below; must be tunable in 500 KHz steps; must be capable of setting the operating frequency, data rate, mode and other parameters via external interface/command. Although the ultimate goal will be to have the entire transmitter in one package of the size indicated above, interim alternatives may be acceptable as a stepping-stone toward meeting that goal. For example, the modulator and up-converter section and the power amplifier section of the transmitter could be made as separate packages each conforming to the general requirements identified previously with the end goal of reducing them to one package later. A more detailed set of transmitter design requirements will be provided at the beginning of Phase I execution.

Phase I: Conduct a feasibility analysis to determine the viability of developing a user programmable telemetry transmitter capable of tunable operation from 1.4 to 2.4 GHz and able to support multiple bandwidth efficient modes of operation. Demonstration of a representative prototype during Phase I would be beneficial if possible, but is not required.

Phase II: Develop and demonstrate a prototype system. The prototype will be evaluated to determine if it meets the performance requirements established during the Phase I effort.

Dual Use Commercialization Potential: The research and development for this product will lead to advances in the packaging of wideband RF circuits and complex digital circuits into smaller packages and therefore will be useful for future wireless technologies and products.

Related References:
1. IRIG Document 106-01 Part I "Telemetry Standards"

2. IRIG Document 118-98 Volume I Chapter 5 "Test Methods for Telemetry Transmitters"

3. Multiple references to FQPSK, SOQPSK and Multi-h CPM can be found in the proceedings of the International Telemetry Conference over the course of the past 3 years.

KEYWORDS: Telemetry Transmitter, Multimode, Multiband, Aircraft, Missiles, Programmable, Tunable

AF03-261 TITLE: Infrared/Ultraviolet (IR/UV) Background Monitoring System (IRUVBMS)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Flight Test Center (FTC)

Objective: Develop a real-time, IR and UV free-space, stimulator monitor to operate in an RF environment.

Description: Advanced multispectral stimulators are being developed for DT&E and OT&E to support upcoming weapon systems tests in a radio frequency (RF) anechoic facilities. The infrared (IR) and ultraviolet (UV) image projectors will stimulate sensors up close (approximately 1 foot standoff distances), coupling the projected IR and UV images through a collimating lens. In an intense RF environment, there is a risk that the electromagnetic interference (EMI) may cause unwanted anomalies with the artificially produced IR and UV images. Normally, off-line periodic characterization and calibration procedures are used to validate test data results. But, off-line calibration will not detect image projector anomalies during operation in the RF environment. In addition, equipment that is involved in a test located in an anechoic chamber cannot be taken to a lab for calibration for weeks at a time. A real-time system is needed to monitor the image projectors for unwanted results of EMI interference. A real-time monitoring system can be used to maintain the calibration of multi-spectral scene projectors in the long wave, medium wave and short wave IR and UV spectrums. These multi-color scenes present an image full of challenges, because they will be capable of generating a multi-spectral scene image at update rates to 400 Hz and large field of views (FOV) covering a solid angle of up to 4 pi steridians. The monitoring system needs to provide spectrally discriminated data to observe unintended shifts in the spectral output from the IR and UV projectors over their operational dynamic intensity ranges. The system will have the capability to record data for up to 30 minutes. The system shall be interfaced and time synchronized with the infrared stimulator systems. These IR and UV monitoring technologies will help develop a multi-spectral test environment to test the data fusion algorithms of new and future weapon systems.

Phase I: Investigate different monitoring techniques for the IR and UV spectrums and develop a technique to monitor the image produced by projectors located up close (approximately 1 foot standoff distances) to the sensors being stimulated. Provide the technical data showing the effects the RF environment has on the sensors and that the sensors have on the environment. The final report should include preliminary designs for a test set and estimated costs for the test set.

Phase II: Using the research concepts and system design developed in Phase I, the contractor design of a real-time free space IR and UV Stimulators Monitoring System, for use in an installed system (RF anechoic chamber) environment. The contractor shall initially build an IR free-space monitoring system. The IRUVBMS shall be capable of operating in a stand-alone-test and shall be interfaced with the existing stimulator system. Also, if funds and time permits, the Contractor shall build a UV background monitoring system and demonstrate the capability. The delivered products will include a full report with documentation of the design for both the IR and UV monitors and the hardware, software, operating instructions, and Validation and Verification results for the IR and UV monitors if built.

Dual Use Commercialization Potential: Phase III will include enhancements to both monitoring systems and manufacturer monitors for use in the BAF. Several other government locations need similar instrumentation. A system similar, without the RF requirements, can be used to test any of the IR and UV sensors and sources on the commercial market or maybe modified to operate as security monitors where multiple frequencies need to be observed..

Related References:

1. Infrared Sensor Stimulator (IRSS) Development Project, Project Number: 6-16-NAF, Funds Citation Number: N0001999WX0219D

2. Central Test and Investment Program (CTEIP) Infrared Sensor Stimulator (IRSS) - Preplanned Product Improvement (P3I) Project, Project Number: 6-21-N, Funds Citation Number - N0001901MPABC8D.

KEYWORDS: Infrared, IR, Ultraviolet, RF, Monitoring, Real-time, Testing, Validation, EMI

AF03-262 TITLE: Wideband Telemetry Over Internet Protocol Networks in Real Time (TM/IP)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Flight Test Center (FTC)

Objective: Develop advanced communications techniques to transport streaming serial data received from air-ground telemetry links in real time over Internet Protocol (IP) networks.

Description: The commercial telecommunications industry is moving in the direction of all-IP networks. We perceive a budding opportunity for military flight-test ranges to take advantage of this technology growth and the ensuing availability of lower cost telecommunication products and services. This SBIR focuses on the real-time data acquisition process for air-ground telemetry, which starts at the telemetry transmitter onboard the air vehicle under test and ends at a central ground-based range control center (RCC). The technical challenge is to develop an operationally suitable real-time transport mechanism that satisfies performance requirements for quality of service, time correlation, and maximum latency deviation.

The current generation of telemetry transmitters output streaming Pulse Code Modulation (PCM) frames. Telemetry streams are almost always bulk encrypted at the vehicle end. The most common range standards for modulation are Continuous Phase Frequency Shift Keying (CPFSK) (also called Pulse Code Modulation/Frequency Modulation [PCM/FM]) and Feher Quadrature Phase Shift Keying (FQPSK). Bit synchronizers are used at the receiving end to filter out noise, reconstruct the PCM data stream and to provide a bit clock. Multiple data streams from the vehicle under test are received and demodulated at ground-based telemetry receiving sites. The format of the data output by the receivers is Non-Return to Zero – Level (NRZ-L) PCM. The received telemetry streams are multiplexed and relayed in real time from receiving sites to front-end telemetry processors at the RCC. Currently three different transport systems are used. These are dedicated fiber links, Digital Signal Level 3 (DS3) microwave links, and Asynchronous Transfer Mode/Synchronous Optical Network (ATM/SONET). Each of these methods has advantages and disadvantages. For the dedicated fiber and DS3 microwave methods, data rates up to about 35 Mb/s can be supported but the end equipment is expensive at $30,000 per end. Using dedicated fibers is inefficient for the long term because when all the fibers in the bundle are consumed a new fiber bundle must be laid at a cost of about $65,000 per mile. The DS3 microwave approach is limited by the lack of available frequency spectrum and line-of-sight requirements. The ATM/SONET approach is cheap at $15K per end but currently technology is limited to about 5 Mb/s per PCM stream. New ATM technology is coming that is targeted at pushing performance to about 50 Mb/s at $10K per end but it will not address all-IP implementation, with its simple network management, performance to match ATM, and cheap hardware (target 50 Mb/s at $5K per end).

From the Air Force's perspective, the desired end-state of this SBIR is to develop an operationally suitable capability to employ IP networks for transporting telemetry. It is anticipated that the IP network method will augment existing methods, and eventually replace them. This SBIR effort seeks to incrementally advance the current state of the art, thereby supporting the Air Force's long-range vision of an all-IP telemetry network (from the aircraft to the desktop). One of the technical challenges to developing a method for transporting air-ground telemetry over IP networks is "timing reconstruction" at the front-end processor. In the past, the Air Force has accepted the burden of higher life-cycle cost and greater operational complexity in order to achieve its performance goals for transporting telemetry steams in real time. As the commercial sector develops commercial off-the-shelf (COTS) solutions to implement Quality of Service (QoS) and guaranteed bandwidth over IP networks, the Air Force will seek to leverage these capabilities by developing the telemetry over IP network capability. Over time, the requirement to transport data from legacy systems over IP networks will increase. Inter-range networking will follow the commercial sector and either the telemetry capability will become integrated or it will require a very expensive overlay network to provide the required service. The task at hand is to conduct advanced development of communications service adaptation equipment to provide telemetry in real time over IP networks. The equipment needs to interface telemetry standards, e.g., Inter-Range Instrumentation Group (IRIG) 106-01, to telecommunication industry standards via dedicated Intranets or via the public Internet. It must accommodate a wide range of telemetry bandwidths (128 kb/s and up), be flexible in providing broadcast, multicast, or point-to-point connections, and be cost efficient. Issues to consider in the proposal include quality of service, latency, delay variations, frequency stability, and synchronization. The proposed solution must also be suitable for transmission over existing ATM/SONET. The SBIR should evaluate the feasibility of developing wire/fiber IP solutions that could work seamlessly with wireless networks.

Phase I: Conduct a feasibility assessment of current IP network technology and propose a recommended system design including technical and cost trade-off findings and recommendations.

Phase II: Develop a prototype capability and demonstrate it at the Air Force. The demonstration results will be evaluated by Air Force and other Services to determine how well it satisfies their needs and shortfalls. The operational suitability of future deployable Phase III systems will be inferred from the Phase II results.

Dual Use Commercialization Potential: This solution may be in the development path of, and provide risk reduction to, the Third Generation Range/Space Wireless Network (3G RSWN) development project. Many other applications to commercial and defense related fields are envisioned, including (1) enhancements to existing communication systems across multiservice installations, (2) data interfaces, (3) inverse multiplexers, and (4) ATM switches. Other expected beneficiaries of this technology are military acquisition projects that have requirements to conduct flight-testing of aeronautics, propulsion and avionic systems.

Related References: IRIG 106-01, PART I - Telemetry Standards, PART II – Telemetry Networks, February 2001

KEYWORDS: wideband telemetry, Internet Protocol

AF03-264 TITLE: <u>PC Based Dynamic Real-Time Infrared Image Generation Capability</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Flight Test Center (FTC)

Objective: Develop a PC based dynamic real-time IR scene generator to drive a 512X512 pixel array.

Description: The PC based infrared scene generator (IRSG) project will provide dynamic real-time missile frame rates and frame sizes to exercise a system under test (SUT) in a closed-loop, real-time HardWare In the Loop (HWIL) environment. In addition, the dynamic scene generator will react to reticule based infrared (IR) seeker, SUT, and scenario changes to produce a scene based on the unfolding engagement scenario just like the "real world." The SUT's viewpoint to the target is always changing in aspect and range as it closes on the target and thus, the SUT will change its viewpoint dynamically to correct its flightpath or trajectory. In the dynamic scene generator, the target's aspect or viewpoint is presented or regenerated dynamically each frame for the SUT to react upon in real time during the HWIL simulation run. The high fidelity scene contains dynamic 6 degrees of freedom (6DOF) airborne targets and countermeasure in a real-world background of clutter, chaff, weather. The output from the PC based IRSG has to drive WISP III resistive array electronics. The WISP III electronics will in turn drive the 512X512 array that radiates through free space to the seeker under test. The signal processing must provide up to 16 bits of thermal resolution, and include a variable frame rate from 50 to 400 Hz.

The objective of this SBIR Topic is to design, develop and demonstrate a prototype for high-speed, low cost scene generation hardware. In time, we hope that the PC-based IRSG will replace workstation-based systems, which are very expensive and have long maintenance tails. This PC based system is intended to demonstrate the feasibility of producing and processing real-time image data with 16-bit pixels at rates of 50 to 400 Hz.

Key functions of the scene generator include the following:
1. Input of industry standard 2D imagery and 3D geometry target models, specifically addressing SPIRITS and CHAMP
2. Efficient real-time rendering of input database
3. Input of real-time simulation data
4. Digital image processing capability
5. Output of real-time correlated scenes at deterministic rates and minimum latency
6. Movable image point of radiance (eye point)

Phase I: Conduct research to evaluate the viability of a PC Based Dynamic Real-time IRSG design. Develop a system design and make recommendations on the construction of the system. Describe hardware and software requirements. Submit a report covering the approach, design and results.

Phase II: Manufacture a working prototype PC Based Dynamic Real-time IRSG system. Deliver and demonstrate the working prototype PC based IRSG. Deliver a final report documenting the performance and capability.

Dual Use Commercialization Potential: Provide PC based IRSG to many DOD and contractor IR test facilities. In addition to the military applications, a PC based system will be useful to smaller companies in the evaluation and testing of optical and IR systems, such as cameras, sensors, and recorders.

Related References:
1. Real-time Synthetic Environments for HWIL Testing (http://www.dtc.army.mil/hpcw/1999/burrough/)

2. Infrared Scene Generation at Stanford (http://www-tsd.stanford.edu/eaton/tempctrl/cooper/IRTV/)

3. Mirage - Innovations In Infrared Scene Simulator Design (http://www.indigosystems.com/PDF/Whitep.pdf)

4. Commercial Terrain Visualization Software Product Information (http://www.tec.army.mil/TD/tvd/survey/IR_Scene.html)

KEYWORDS: PC based IRSG, Infrared, Optical, Real time, Missile, Infrared, IR target, Optical, Missile countermeasures

AF03-265 TITLE: <u>Reduction of Arsenic in Water</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Flight Test Center (FTC)

Objective: To develop a cost effective technique for removing arsenic from well water to meet the new EPA arsenic standards for safe drinking water.

Description: A commercial water treatment system is needed that is cost-effective and able to meet the Environmental Protection Agency (EPA) recent reduction in the maximum allowable arsenic in drinking water from 50 to 10 parts per billion (ppb). This need is especially urgent for small communities and installations that serve fewer than 10,000 people each, which constitute 97% of the water systems affected by this rule. Treatment systems for such communities must be highly economical, as costs must be borne by relatively few users. Cost-effective water treatment requires both removal and destruction of contaminants, while minimizing equipment, and maintenance and operating (O&M) costs; such techniques as in-line scrubbing of filter media would reduce O&M costs. Therefore feasibility and prototyping must take into account both technical and economic parameters.

Arsenic is a semimetal and is a member of the nitrogen family. Many groundwater sources in the western United States are contaminated with naturally occurring arsenic, which is carcinogenic to humans at concentrations as low as 50 ppb. In addition to naturally occurring sources, Arsenic is also thought to enter groundwater systems through contact with brines used in the production of oil and natural gas. Once in the groundwater arsenic can combine with a variety of compounds to form arsenicals. The arsenicals can be both organic and inorganic, with the latter being the more toxic.

With growing concerns about public safety, compounded by water shortages throughout the western United States and new limits on arsenic in drinking water, development of an effective method for the removal of arsenic from contaminated groundwater is critical. The new lower arsenic limits, which take effect in 2006, will not be waived or deferred by the EPA for communities and installations, even those with supporting technology in development. Hence the urgency and the potential benefits of moving rapidly toward understanding and developing microwave energy as a solution to provide safe drinking water for the needs of small communities.

Phase I: The work conducted under Phase I of the proposed research would prove the concept and model the cost-effectiveness of removal and destruction of arsenic in drinking water. Contaminants of interest, in addition to arsenic, include perchlorate, permanganate, dioxin, chromium 6 and other water-soluble heavy metal ions. The throughput capacity and scale economies of the proposed system would be evaluated to determine the feasibility of the technology at different sizes.

Phase II: From the applied research and preliminary technology development in Phase I will come the creation of a working, scaled-up prototype in Phase II. An actual working system would be designed, built and tested in the laboratory using actual or simulated arsenic-contaminated water. Key considerations would be the ability to destroy arsenic compounds in water and reduce the overall arsenic concentration to meet the new EPA arsenic standards for drinking water.

Dual Use Commercialization Potential: From the development of a working prototype in Phase II will come key information about the performance of the system and how to modify it to achieve the most cost efficient destruction process for field treatment of arsenic compounds in water. This information will allow the design and installation of a commercial prototype for demonstration at small community water treatment installations and/or Military Bases.

Related References:
1. World Health Organization Fact Sheet No 210: Arsenic In Drinking Water (http://www.who.int/inf-fs/en/fact210.html)

2. International Programme on Chemical Safety Environmental Health Criteria Monograph No. 224 Summary (http://www.who.int/pcs/ehc/summaries/ehc_224.html)

3. Environmental Protection Agency Office Of Ground Water & Drinking Water Arsenic Page (http://www.epa.gov/safewater/arsenic.html)

4. National Academy Press "Arsenic in Drinking Water: 2001 Update"
(http://www.nap.edu/books/0309076293/html/)

KEYWORDS: arsenic-contaminated water, EPA, drinking water

AF03-266 TITLE: Simulated Clutter for Airborne Radar Evaluation (SCARE)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Flight Test Center (FTC)

Objective: Demonstrate the capability to present time-correlated and spatially distributed clutter to the system under test (SUT).

Description:. Ground testing of modern radar systems requires the ability to present the test radar with an accurate representation of the radio frequency (RF) environment (as would be seen in flight). Current systems are available to present targets to the aircraft’s radar system via free space from antennae located various angles around the radar antenna. While, antennas placed at fixed locations (in Azimuth and Elevation) can accurately represent targets; clutter is present in nearly all azimuths and elevation angles and must be presented with different signals from multiple angles simultaneously. Modern Radars use advanced processing techniques to detect and then minimize the effects of clutter to increase the probability of correctly locating and tracking targets. These processing techniques use the return signal amplitude, Doppler, angle (Azimuth and Elevation), and variations of these components over time to help improve the probability of correctly detecting and tracking targets in clutter. To test an installed radar system in a realistic free-space environment, clutter must be generated to exhibit characteristics, which correctly simulate the “real clutter’s” effect on the airborne radar performance. The Simulated Clutter for Airborne Radar Evaluation (SCARE) capability shall simulate correct amplitude, time delay and Doppler of the modeled clutter by radiating signals from spatially correct angular locations, magnitudes and phase angle. This capability shall collect transmitted information via free space, add the clutter modulation and transmit the resulting signal at the proper time to correlate with the target return. Further more this capability shall be operate with modern airborne radars in the 8-12 GHz frequency range.

Phase I: This research effort includes researching the methods of stimulating a radar system with free-space clutter. Possible solutions showing different methods of presenting time, magnitude and phase correlated signals from multiple angles will be developed and evaluated for feasibility, cost and performance. The final product shall include a technical report presenting the analysis and results of the Phase I efforts, which should include the recommended solution, and the engineering data package suitable for proceeding to phase II.

Phase II: Develop and construct and deliver a small a proof of concept system and demonstrate its operation. Submit a final report on the development and test results and, if feasible, a cost analysis of a full-scale system and how it may be used with other stimulator systems

Dual Use Commercialization Potential: This capability is directly applicable to commercial contractor facilities used to develop, test and evaluate commercial and military airborne radars and EW systems. The clutter stimulation system developed under this effort may be used for testing commercial aviation collision avoidance systems and advanced aviation weather radar systems. If this system is usable for radar it could also be useful in testing cell and mobile phone frequency selection algorithms in a realistic environment.

Related References:

1. Skolnik, Merrill: "Radar Handbook (Second Edition)", McGraw-Hill Inc, 1990, Chapter 12.

2. Stimson, George W.: "Introduction to Airborne Radar (Second Edition)", SciTech Publishing, Inc., 1998, Chapter V.

KEYWORDS: Clutter, Radar, Doppler, Monopulse, Testing, Modeling

AF03-268 TITLE: Direct Energy Countermeasures Stimulator System (DECSS)

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace, Space Platforms

ACQUISITION PROGRAM: Flight Test Center (FTC)

Objective: Develop a capability to test directed energy infrared and laser based countermeasure systems.

Description: Infrared (IR) guided missile threats have proliferated and must be countered to improve military and commercial aircraft survivability. Systems under development to counter these threats include the Large Aircraft IR Countermeasures (LAIRCM) program, the Special Operations Command's (SOCOM) Directed IR Countermeasures (DIRCM) system, and the Navy's Tactical Advanced Directed IR Countermeasures (TADIRCM) system. The DIRCM also employs directed IR countermeasures to defeat IR missile threats. To fully test directed energy countermeasure system's tracker performance and jam head pointing accuracy, the DECSS system will need to employ a co-located IR sensor to monitor the energy being directed at the simulated missile with the IR stimulator that is mimicking the threat missile IR signatures. The challenge is to develop a test capability that allows directed energy IR countermeasure system testing, which supports the threat signature stimulation requirements for the LAIRCM, TADIRCM and DIRCM systems, operating both in a stand-alone mode and by interfacing to the Infrared Sensor Stimulator (IRSS) system. Elements of the existing IRSS stimulator capability can be utilized and incorporated into the proposed system. The feasibility, level of effort, cost, and risks must be researched and assessed before development of a real-time system can begin.

Phase I: Research the feasibility of developing a Directed Energy IR Countermeasures Stimulator System for use in an installed system test facility (radio frequency (RF) anechoic chamber) environment, and develop a preliminary design that will meet testing requirements.

Phase II: Using the research concepts developed in Phase I, develop a graphical user interface (GUI) driven Directed Energy Countermeasures Stimulator System (DECSS) and demonstrate the capability to support an installed system (RF anechoic chamber) environment. The DECSS will be capable of operating in a stand-alone-test and by interfacing with the existing IR Sensor Stimulator system. The Delivered products will include the Program Management Plan, development, implementation, and verification and validation plans.

Dual Use Commercialization Potential: The proliferation of handheld IR antiaircraft missiles posses a grave threat to commercial aviation, as well as military. The military is installing protection for its aviation assets. Commercial aviation could equip some aircraft with protection, such as directed energy countermeasures based on lasers. These devices would require periodic testing to ensure operational capability. The DECSS system could provide test capability for field level operational and functional test and evaluation of minimum standards.

Related References: "Low Cost Calibrated, Portable, Computer Controlled Variable Output IR/UV Source" AF96-217, SBIR Contract F04611-97-C-0076. (http://www.edwards.af.mil/sharing/docs_html/sbir/fy-961.htm or http://www.sbirsttr.com/Awards/Default.asp)

KEYWORDS: Direct Energy Weapons, Infrared, IR, Stimulator, Real-time, IR Missile Threats

AF03-269 TITLE: Use of Pattern Recognition to Optimize Site Investigation

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: OC-ALC

Objective: Develop a way to use pattern recognition to optimize contaminated site investigation.

Description: Many contaminated groundwater sites exists on various Air Force Bases as well as Department of Defense (DoD) facilities around the world. One of the keys to successful and complete site remediation is the ability to located the source of the contaminant plume. As a part of site investigation, many different types of data have been acquired over the years. The ability to combine the various data types for use in one site investigation will enable more precise contaminant plume delineation which then enables optimal remedial system design and installation. In addition, this innovative research will optimize the use of various data that commonly exists at contaminated sites around the world.

The success of remedial technologies depends upon thorough delineation of the dissolved phase and the source zones of a contamination plume. Pattern recognition is an innovative technology that would gather the various different data types that are typically collected and evaluated separately at contaminated sites (ie- geophysical, soil, contaminant, groundwater data), and would combine them via geostatistics and modeling in a single data set which then could be used to define the subsurface configuration of the contaminant plume. This is a great advantage over using the various data types individually in order to delineate the contamination, particularly in heterogeneous media. Additional benefits would be the ability to streamline the collection of site data such that only the minimum amount, as well as the appropriate type, of data would be acquired given site specific parameters.

At the vast majority of contaminated sites, a large amount of site data is acquired in order to fulfill the Environmental Protection Agency (EPA) requirement for site delineation. Normally, additional data is required in order to fully design and implement a remediation effort. The accumulated cost of data acquisition for this site investigation can be overwhelming. Innovative technologies such as pattern recognition would enable the capability of selecting only the type of data that would be necessary in order to adequately delineate and remediate the site. This would not only save dollars that might be spent on non-critical data acquisition, but would also enable the maximum use of data that already exists at most sites. Because the data already exists, the ability to 'streamline' and optimize the site investigation utilizing already existing data would yield more "bang for the buck".

Phase I: Research and analyze which data types are more indicative of dissolved and/or free-phase Dense Non-Aqueous Phase Liquid (DNAPL) presence at a site and use this information to develop a site conceptual model indicating plume characteristics and location. Also, determine what data types are more conducive to the use of pattern recognition.

Phase II: Based upon the results of Phase I, which would yield estimates of site characterization, field confirmation would be utilized in order to confirm the site conceptual model. Based on the field results, application of the technology would be refined for possible use at other sites.

Dual Use Commercialization Potential: If successful, this technology could be applied on a worldwide basis at any contaminated site where a typical site investigation consists of multiple data types. Often, the success (or lack thereof) of a new technology is determined on a site-specific basis. For example, a certain technology may work on the specific site parameters at a test site, but that success often is not transferable to the majority of sites. The fact that this technology can utilize many varying types of data allows for flexibility to use at any site worldwide.

Related References:
1. "The Pattern Recognition of AI", website: www.dontveter.com/basisofai.basisofai.html

2. "Pattern Recognition", website: www.elsevier.n/inca/publications/store/3/2/8/index.htt

3. "What is Cluster Analysis", website: www.clustan.com/what_is_cluster_analysis.html

4. "Discriminant Function Analysis", website: www2.chass.ncsu.edu/garson/pa765/discrim.htm

KEYWORDS: Cluster Analysis, Pattern Recognition, Function Analysis

AF03-270 TITLE: <u>Adapting Bar Code Readers to Hand Held Elector-Optical Wiring Inspection Devices</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: OC-ALC

Objective: Most aircraft wiring harness manufacturing and maintenance activities rely on an operator reading and interpreting the identification numbers printed on individual wires and sorting through an extensive collection of printed documents to determine the relevant interconnection data. Identification numbers on smaller gage wires are somewhat difficult to read during the manufacturing process and become a significant challenge when attempting to service installed harnesses in operational aircraft. Limited access, poor lighting and the random placement and orientation of these numbers on individual wires are a major problem for the aircraft maintainer. This time consuming practice continues in spite of the extensive investment that is being made by air vehicle manufacturers in documenting the related manufacturing and maintenance data in electronic data base systems. Wiring inspection technologies that do not require the disassembly of components will help to reduce maintenance manhours. In order to take advantage of the increasing availability of electronic wiring data, an improved means of determining these numbers and accessing related interconnection data needs to be developed.

Description: One possible approach to providing an automated link between the wire identifier and related electronic data is bar coding. Laser wire identification marking is gaining increased usage by air vehicle manufacturers. Although limited in height by the wire diameter, hand-held readers with a negligible error rate can now interpret laser-marked bar codes. Bar coded equivalents to conventional alphanumeric wire identification numbers could be used to enable instantaneous access to interconnect information through a direct link to the electronic wiring database. This process is similar to the edit-find function common to word processing and spreadsheets systems. One of the major difficulties in reading such bar codes is the need to align them with the current-technology reading devices. This requires rotating each wire until the number is accurately aligned with the reading device viewer. This same problem exists with to a lesser extent with aligning conventional alphanumeric identification numbers with the operator's line of site. Although this alignment process is inconvenient for individual loose wires, it is typically impossible in an assembled harness without cutting away numerous cables ties and often requires de-pining the nearest connector.

Hand held electro-optical wiring inspection equipment has recently demonstrated the ability to view 360 degrees of the wire surface with up to 10x magnification. This capability eliminates the need to rotate wires to any particular orientation. Through character recognition software, such equipment could be used in the assembly shop and on installed harnesses to read either alphanumeric or bar coded wire numbers, providing the desired link to an interconnection database.

Phase I: Investigate commercial bar code readers, with a focus on adapting this technology to hand held electro-optical wiring inspection devices. Investigate character recognition software; such as is currently available with computer scanning devices, as a means of interpreting alphanumeric wire numbers or bar codes. Develop a proof-of-concept 360-degree reading device that can export the electronic equivalent of typical wire code numbers or bar codes to an electronic database. Demonstrate this capability by displaying the identification code number on a standard personal computer screen display.

Phase II: Develop a prototype 360-degree reader that is suitable for use as a portable handheld device to be used in the assembly shop or an installed aircraft wiring. Develop a prototype adapter for bench mounting use of the subject device in an assembly shop. Conduct testing to evaluate the accuracy of the reading device under various conditions in the harness shop and on completed aircraft. Examine test results and modify the prototype hardware as necessary for application in all phases of anticipated use. Deliver 5 sets of prototype hardware for Beta site testing.

Dual Use Commercialization Potential: Evaluate assembly, installation and maintenance techniques that utilize the wire code reader for accessing electronic wiring data. Evaluate portable and fixed screen display devices that can be used with the reader. In coordination with a software developer and an air vehicle manufacturer, conduct a demonstration project to evaluate the benefits attendant to incorporation of this device as a production tool and as an aircraft maintenance aide. Develop a set of guidelines for adapting the viewer and display devices to access a various formats of electronic data that are used in the air vehicle industry.

Commercial Potential: The proposed wire code reader and associated displays can be used for any type of wiring application that employs some type of wire marking/numbering system to identify individual wires.

Related References: Website http://www.laselec.com/an/news.htm

KEYWORDS: Bar code, 360 degree viewer, electronic wiring data, inspection device, screen display

AF03-271 TITLE: Knowledge Capture and Re-use in Maintenance, Repair, and Overhaul

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: OC-ALC

OBJECTIVE: Develop a system to capture and manage the tacit knowledge at the depots

DESCRIPTION: The Department of Defense (DoD) is facing significant challenges in maintaining weapon systems that are more than 40 years old and expected to remain in service indefinitely while realizing targeted reductions in sustainment costs. Moreover, the knowledge base for maintaining these systems is dwindling with attrition and retirement of the aging work force. While the depots are concentrating on replenishing their aging workforce, we need to concentrate on making the current workforce more efficient and capture their knowledge for use by the next generation of workers. Much research has been done in the area of knowledge-based product development and engineering. However, research in the area of knowledge capture and management is lacking, especially in all areas relevant to maintenance activities. DoD is seeking a system that can capture and manage the tacit knowledge at the maintenance depots. Using this system, any depot worker should be able to communicate the rational behind decisions made at any stage of the maintenance process. We are looking for a generic ability to electronically express, capture, exchange, and reuse knowledge in a meaningful way. This requires an environment that will allow "knowledge-based" maintenance, repair, and overhaul through an effective integration of worker knowledge and supporting technologies at all levels of the organization. A metric in practicing this so-called Knowledge-Based Maintenance (KBM) methodology is the ability to provide the right information to the right personnel at the right time and in the right format. By having a formalized and controlled decision support system, with a knowledge base and reasoning backbone, we can gain from existing rules, requirements, and maintenance expertise to shorten the overhaul cycle.

Phase I: Select a DoD depot that is using a work portal on the shop floor (e.g., Tinker AFB) and research the best knowledge capture methodology for that depot. Based on the results of the research performed, develop a concept demonstration and define metrics for assessing the program for Phase II.

Phase II: Develop and demonstrate a prototype system in a realistic shop environment. Conduct testing to prove feasibility of a full operational capability. Prove the viability to the management of the depot using the metrics set in Phase I. Prepare a detailed final report on the lessons learned and implementation procedures.

Phase III Dual Use Applications: With minor modifications, the implemented knowledge-based maintenance system could be utilized in any industry that involves tools. The tool could be applied for any process improvement or re-engineering business process.

References:

1. Chen, P. (ed.) Data & Knowledge Engineering, North Holland Publishing Company, Vol. 7, 1991.

2. Crabb, H.C. The Virtual Engineer, 21st Century Product Development, SME/ ASME Press, New York, 1998.

3. Penoyer, J.A., Burnett, G., Fawcett D.J., and Liou, S-Y, Knowledge based product life cycle systems: principles of integration of KBE and C3P, Computer-Aided Design, Vol. 32, Numbers 5-6, pp. 311-320, 2000.

4. Gero, J.S., Sudweeks, F. (editors) Artificial Intelligence in Design, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1998.

KEYWORDS: Knowledge-based management, knowledge capture and re-use, maintenance decision-support

AF03-272 TITLE: <u>Use of Electrokinetics to Enhance In-Situ Remediation of Chlorinated Organic Contaminants in Groundwater</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

ACQUISITION PROGRAM: OC-ALC

Objective: Develop a way to use electrokinetics to enhance in-situ remediation of chlorinated organic contaminants in groundwater.

Description: Many contaminated groundwater sites, on various Air Force Bases, contain chlorinated solvents such as trichlorethene (TCE) and perchloroethene (PCE). New in-situ treatment techniques including the injection of substances such as chemical oxidants, amendment addition and bio-augmentation have been successful in enhancing the bioremediation of contaminated soil and groundwater. However, due to the existence of preferential pathways in the subsurface, uniform delivery of these enhancing substances are problematic. Short-circuiting of the contaminated area can occur, resulting in a futile remediation attempt. Without adequate saturation of the contaminated media with the injected material, optimal remediation levels will not be attained.

The subsurface geology at the vast majority of contaminated sites world-wide is highly heterogeneous. Preferential pathways such as subsurface sand channeling influence the location and migration of contaminant plumes. The success of amendment technologies for site remediation depends on the adequate delivery of the amendment throughout the contaminated zone. While it is currently recognized by the industry as a problem, current in-situ chemical and bioremediation enhancement technologies do not address the delivery issue. The use of electrokinetics in remediating TCE and PCE in groundwater is an innovative modification of the enhancement technology in that it attempts to evenly distribute the amendment throughout the contaminated zone.

Electrokinetics will use electrical potential to move ions through saturated soil and groundwater. Electrodes are placed in the subsurface and will attempt to ‘guide’ ionic oxidants such as permanganate throughout the subsurface. This innovative technology is a way to force the amendments through the less porous zones in the subsurface thereby accomplishing more even distribution throughout the contaminated zone. The ionic strength of any amendment could be enhanced by the addition of higher ionic strength material to the amendment.

It is important to note that while the use of electrokinetics has been proven successful in the remediation of metals in soil media, it has yet to be applied to chlorinated organic constituents contaminating the groundwater. Groundwater contaminated with chemicals such as TCE, PCE and DCE is both at DoD facilities as well as the majority of contaminated sites worldwide.

Phase I: Evaluate site specific parameters required to optimally apply the technology using ionic oxidants such as permanganate as well as bioamendments such as lactate, vegetable oil. Based on those results, perform pilot scale testing at a selected site.

Phase II: Using the results of the pilot scale test, refine the technology as needed and perform a full scale test.

Dual Use Commercialization Potential: If successful, this technology could be commercially applied on a worldwide basis at any contaminated site where preferential pathways in the subsurface act to inhibit the delivery of injectables evenly throughout the contaminated zone. Often, the success (or lack thereof) of a new technology is determined on a site-specific basis. For example, a certain technology may work on the specific site parameters at a test site, but that success often is not transferable to the majority of sites due to variations in site characteristics. Given that the geology at Tinker AFB is highly heterogeneous, if the technology proves successful at Tinker AFB, then it should be successful at the vast majority of contaminated sites worldwide.

Related References:

1. "Electrokinetics", by Liesbet Van Cauwenberghe, GWRTAC, Report #TO-97-03, July 1997.

2. "Chlorinated Ethylene Treatment via In-Situ Chemical Oxidation and Electrokinetics Technologies", Scott Waisner, Draft Workplan, January 9, 2001.

3. "Electrokinetics", Website http://www.cpeo.org/techtree/ttdescript/electro.htm

KEYWORDS: Electrokinetics in Groundwater, Chemical Oxidation Delivery, In Situ

AF03-274 TITLE: <u>Graphical Index for Aircraft Legacy Data</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: OC-ALC

Objective: Develop a system that can assist the aircraft mechanic/engineer in graphically viewing information

Description: The Department of Defense (DoD) is facing significant challenges in maintaining weapon systems that are more than 40 years old and expected to remain in service indefinitely while realizing targeted reductions in sustainment costs. The legacy data is mostly paper or raster based with little to no intelligent information. Research is needed to provide a capability to search on, retrieve and view legacy Weapon System geometry, parts list, engineering notes, technical descriptions, , etc. independent of the applications used to author the data. The capability is applicable for a variety of functions essential to the maintenance of aging aircraft, i.e. re-engineering, manufacturing, planning, line maintenance, data management, and contracting.

Although the emergence of internet/intranet technology opened countless doors with respect to information acquisition, the only method of executing an information query has been through textual association. There now emerges a need for Shape Searching Technology that renders users capable of locating shapes and extracting geometric design information relevant to their specific tasks, be it design, process planning, manufacturing, or contracting. This emerging technology is yet to be fully developed in the context of weapon system legacy drawing vaults or extended to the weapon system solid models regardless of native Computer Aided Design (CAD) software or file type used. The completed tool will provide a means to populate Product Data management Product Structure modules saving significant labor hours in establishing and maintaining legacy product data structure systems.

Phase I: Select a DoD depot that is using a work portal on the shop floor (e.g., Tinker AFB) and research the best legacy data capture methodology and indexing mapping for that depot. Then develop a concept demonstration and define metrics for assessing a design requirement.

Phase II: Develop a prototype in an actual depot environment that is indexed to real legacy systems that is based on the results of Phase I concept and requirements. Prepare a detailed final report on the lessons learned and implementation procedures.

Dual Use Commercialization Potential: With minor modifications, the implemented Index Mapping Methodology could be utilized in any industry Original Engineering Manufacture of DoD weapon systems. The tool could be applied for any aging weapon system of raster based legacy data.

Related References:
1. The American Society of Indexers - http://www.asindexing.org/site/

2. Search Engine Terms - http://www.cadenza.org/search_engine_terms/

3. An XML Framework for coordinating creative & technical design – http://www.intranetjournal.com/articles/200108/gb_08_01_01a.html

4. Object and Knowledge Based Systems Consortium - http://www.cs.cf.ac.uk/research/oks.html

KEYWORDS: Geometric Shape Search Technology, Product Structure, Web Based Indexing

AF03-275 TITLE: Wireless Asset Tracking, Matching, and Management

TECHNOLOGY AREAS: Information Systems, Materials/Processes

ACQUISITION PROGRAM: OC-ALC

Objective: Develop a wireless system that can manage and track tools and other assets in a depot shop.

Description: A system is required for tracking tools using wireless locators, matching those tools with the task being performed, and ensuring the availability and accountability of tools using a management system. Wireless locators are small devices that can be attached to pieces of equipment and tools to know their whereabouts at all times. These small devices will automatically alert the network if tampered with or removed. There are mainly two types of systems that wirelessly track both people and assets. One uses the Global Positioning System (GPS) and cell phone technology to report the location. The other one uses the less expensive radio frequency identification (RFID) for tracking. A tracker who wants to discover the location of a trackee submits a request through a web page on the server. In the GPS-based system, the server then "calls" the locator, asks for a position fix, and then draws a map showing the current location of the tracking device. In the RFID-based system, the location is identified by an array of antennas that sense the location of small tags with built-in radio transmitters. RFID systems lack the ubiquitous coverage of GPS-based technology, but the cost of RFID systems can be much less.

Uniquness of the Proposed System: The current commercial tracking packages, based on either GPS or RFID, do NOT include asset management. Moreover, they do not attempt to match tools with specific repairs or specific mechanic and preclude any data mining to allow predictive analysis on the usage of tools. Also, the commercial systems only report the location of the tool and do not maintain a relationship between the tool and the individual that currently has the tool. By combining the current asset tracking technologies with people/process management software and a work portal, we can ensure that tools are always available and maintain a relationship between tool, task and the individual worker. Such a system helps in capturing the knowledge about tool usage in the context of a task, in addition to tracking and managing the assets in a depot shop. Additionally, this system can be used to ensure that, at the end of a work day, the personal tools are all accounted and located in the appropriated location (e.g., toolbox). If any tool is misplaced, its current location can be quickly identified.

Phase I: Select a DoD depot that is using a work portal on the shop floor (e.g., Tinker AFB) and research the best asset tracking technology for that depot. Then, develop and demonstrate a concept for tracking tools/equipment using wireless locators utilizing industry standards and open systems. Also, define the necessary metrics for assessing a Phase II prototype system.

Phase II: Develop a prototype in an actual depot environment that fully demonstrates tracking and locating of tools/equipment at the depot in their wireless infrastructure based on the results of Phase I concept and requirements. Prepare a detailed final report on the lessons learned and implementation procedures.

Dual Use Commercialization Potential: With minor modifications, the implemented tracking system could be utilized in any industry that involves tools.

Related References:
1. The home for information on RFID technologies:
http://www.rfid.org

2. The home for information on GPS technologies and resource library: http://www.gpsy.com/gpsinfo/

3. The home of a company selling a commercial system based on RFID technology:
http://www.edcsolutions.com/exi.htm

4. The home of a company selling a commercial system based on GPS technology:
http://www.wherifywireless.com/consumer/

KEYWORDS: Wireless asset tracking, Radio Frequency Identification, tool/employee matching and management

AF03-279 TITLE: Low-Cost Composite Materials/Additives that Provide Resistance to Direct Solar Ultra-Violet (UV) Radiation Deterioration

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: OO-ALC

Objective: Develop and demonstrate low cost, high performance composite materials/additives that when exposed to direct solar radiation will maintain mechanical properties without additional overcoat protection i.e paint/coating related process over the 30 year life cycle of DoD next generation 100% composite shelters.

Description: Air Force Tactical Shelters are deployed in various austere environments that involve extended exposure to direct solar radiation. UV radiation typically degrades exposed composite materials reducing lifecycle to 1-3 years. Current technology requires overcoat protection of some kind to mitigate material degradation Environmental constraints regarding the pollution effects of the overcoat/painting process in both manufacturing and field maintenance makes this unacceptable. The objectives of project are as follow: (1) Eliminate environmental burdens associated with overcoat/paint processes (2) Reduce maintenance costs (3) Comply with ASTM E1925 for human occupation.

Phase I: Conduct research and determine feasibility of composite materials/additives that are not affected by direct solar, UV, radiation for application in composite tactical shelters and the following target capabilities: (1) The composite materials must be low cost and yield shelter configuration that can be readily deployed IAW Specifications for Engineering and Design Criteria For Rigid Wall Relocatable Structures (ASTM E 1925), (2) The composite materials/additives must not compromise minimum flexural strength, impact resistance, fire resistance in addition to providing UV solar resistance. (3) Must be adaptable to current shelter manufacturing technologies/processes.

Phase II: Design, fabricate, and test prototype composite sandwich panels for UV deterioration, mechanical strength, fire resistance and impact properties in accordance with ASTM E1925. Design and build prototype shelter components to allow pilot plant manufacturing of composite shelters.

Dual Use Commercialization Potential: A UV resistant composte material/additive will have numerous benefits for DoD and industry as well as reducing environmental impact.

Related References:
1. Merkle, D.H., New Family of Portable Shelters, Vol.2, Air Force Research Laboratory Report No. WL-TR-97-3032, May 1998.

2. ASTM E 1925, Specification for Engineering and Design Criteria For Rigid Wall Relocatable Structures.

3. Jana, P.B., Mallick, A.K., De, S.K., Ch.7 in Short Fibre Polymer Composites, De, S.K. and White, J.R., Eds, Woodhead Publishing, LTD, Cambridge, England, 1996.

4. Natick Soldier Center, DOD Standard Family of Tactical Shelters, January 2000.

5. Advanced Composite Structures: Fabrication and Damage Repairs, Abaris Training, May 1998.

KEYWORDS: Composite, Shelter, Solar, Radiation, Ultra-violet, UV, Shielding, Low cost

AF03-280 TITLE: Ultra High-Resolution Visual System Development

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: OO-ALC

Objective: Development of advanced ultra high-resolution visual system components for Distributed Mission Training (DMT) that provides eye-limiting resolution everywhere the eye looks. Of particular interest to this solicitation well be novel concepts to develop ultra high-resolution visual system components for future DMT simulator-based training. Many legacy training systems, under sustainment, are either presently DMT capable to some degree or soon will be; DMT has been mandated at the DOD level as critical to aircrew training for weapon systems at all life-cycle stages. Developments in this area would certainly be applicable as technology insertion modifications to these legacy-training systems.

Description: One of the significant technologies being developed for DMT is ultra high-resolution image generation and display systems. The resolution, field-of-view, brightness, and contrast of practically every visual system available today is far less than what the pilot sees looking out of the real aircraft. The resolution of current out-the-window displays is at least an order-of-magnitude less than required. Because of this, current visual systems do not provide a pilot with adequate visual definition to identify other aircraft, ground vehicles, roads, and bridges at realistic tactical ranges or to properly assess their aspect angle. The focus of this solicitation is to support the development of reliable, easy to maintain visual system technologies with resolution, contrast, and fidelity required for realistic air-to-air and air-to-ground training in a fast moving DMT visual system.

The Air Force is seeking innovative solutions for the development of high-fidelity visual display technology that provide sufficient display brightness, contrast, and resolution to support eye-limited acuity for fast-moving target, background, and surround imagery. Low production cost, high reliability, large commercial potential, and transferability to legacy training systems that are well into the operational phase of their life-cycle are critical requirements for the technology being proposed for this solicitation.

Phase I: Conduct research and determine the feasibility of the concept of an innovative solution for a high fidelity display system as described.

Phase II: Provide a prototype that demonstrates and tests the concept proposed

Dual Use Commercialization Potential: This work, combined with ongoing efforts to increase image resolution, would have immediate benefit to the expanding world of virtual reality for industrial (auto, boat, manufacturing), medical, special effects applications in the electronic media and motion picture industries, and CAD/CAM.

Related References:
1. Niall, K.K. and Pierce, B.J. (2000). Assessment of visual requirements, Aircrew Training: Methods, technologies, and assessments.

2. Wight, D., Best, L., Peppler, P., (1999). M2DART Visual Display, A Real Image Simulator Display System, Aerosense Conf., Orlando, Fla.

3. Pierce, B.J., Geri, G.A. and Hitt, J. (1998). Display Collimation and the Perceived Size of Flight Simulator Imagery. AFRL-TP-1998-0058. Mesa, AZ.: Warfighter Training Research Division, Air Force Research Laboratory.

4. Pierce, B.J., Geri, G.A.,(1998) The implications of Image Collimation for Training Size and Motion-Related Tasks in a Flight Simulator, Annual Meeting of the Human Factors and Ergonomics Society, Chicago, Ill.

5. MacDonald, L.W. & Lowe A.C. (Eds). (1997). Display Systems: Design and Applications, West Sussex, England: John Wiley & Sons Ltd.

KEYWORDS: Helmet Mounted Optics, Laser, Helmet, Simulator, Graphics, High-Resolution, Image Generator

AF03-281 TITLE: Universal Power Sensing and Control Module

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: OO-ALC

Objective: Provide a universal programmable sensing and control module for use with multiple aging aircraft power generation systems

Description: Electrical or electronic aircraft systems typically have customized internal circuitry to protect the avionics systems from undervoltage, overvoltage, underfrequency, and overfrequency conditions. This circuitry usually requires manual adjustments of potentiometers to set the desired tolerances. Over time, the potentiometers can drift, become dirty, or fail. This can result in nuisance tripping, or worse, a failure to protect the avionics systems. Although these modules can be refurbished, they tend to include customized components, which become expensive and difficult to obtain.

This project seeks an innovative method of eliminating the manually adjusted potentiometers and customized adjoining circuitry and replacing them with a common programmable module. The module would provide for robust platform independent power sensing (frequency, voltage, etc.), control outputs (for relays and other switching devices) and methods for the prevention of nuisance tripping. The input tolerances, control output voltages/currents, and nuisance tripping levels would be programmable to the specific aircraft platform. Although the module would be generic, aircraft/platform specific connection adapters would also need to be developed.

Phase I: Conduct research to determine feasibility of designing a prototype, field-functional unit which will retain the functionality of existing circuits but will incorporate innovative electronic methods of sensing and controlling the various power systems. Demonstrate its capabilities by direct comparison with existing field level units.

Phase II: Design, fabricate, test and provide a prototype for developing low-rate initial production (LRIP) units, which can be installed on various aircraft of the Air Force's choosing. Development of additional aircraft specific connection adapters.

Dual Use Commercialization Potential: The proposed functional unit has the potential of being utilized by several weapon systems. Aircraft power systems typically have several similar characteristics, and the portability of the proposed units between weapon systems remains a viable goal and should be actively pursued.

Related References:
1. V. Braidotti, D. Zaninelli, A.Zanini, "Power Quality Studies on Aircraft Electrical Systems", Ninth International Conference on Harmonics and Quality of Power, vol. 2, pp 628-32, (Oct 2000).

2. M. Ehanso and A. Emadi, "Multiconverter Power Systems and Their Applications", Electric Power Components and Systems, vol.29, pp949-63, (Oct 2001).

KEYWORDS: Analog/digital circuitry, Aircraft Power systems, Automatic measurement, adjustment, Aging Aircraft, Microprocessor Based Sensing, Control Systems.

AF03-282 TITLE: Non-Contact, 3-D Measurement for Aircraft Surfaces

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: OO-ALC

Objective: Provide a high resolution, low-cost, portable device to measure the 3-D surface of aircraft surfaces

Description: Many aircraft repair or refurbishment tasks involve operations on the airfoil or control surfaces. Changes in the surface shape, orientation or contour can have a significant effect on aircraft performance but there is no satisfactory device for measuring the 3-D surface profile of aircraft surfaces before and after rework. Current methods use:

Mechanical templates which are inaccurate, cumbersome to use and difficult to store.
Theodolyte triangulation which is slow and cannot be used for closely spaced points
Mechanical articulated linkage devices that must be guided by an operator and placed in contact with the surface
Structured light systems using projected laser light, which are slow and are limited n the area of measurement

All of these methods are slow and require experienced operators to obtain satisfactory results.

This project seeks to develop a 3-D measurement device suitable for use in an ALC environment. The device should be portable so that it can be moved to an aircraft for measurement. Measurements should be made at closely spaced intervals so that a CAD program can compare the measured surface to a reference surface. The measurement resolution must be sufficient to detect surface dents, oil-caning, and deformations caused by over-stressing or processing operations.

Phase I: Conduct research to determine feasibility of designing a prototype 3-D measuring device. The device should be portable, with a target cost of $30,000 or less, and be able to measure surface areas up to 8 ft x 8 ft with a Z-resolution of .010". Demonstrate the device by measuring reference aircraft surfaces and comparing the results with CAD representations.

Phase II: Design, develop and test prototype device suitable for use in an ALC or other aircraft maintenance operation. The end product must include the capability for field calibration and must provide data compatible with common CAD systems.

Dual Use Commercialization Potential: A high resolution, 3-D measurement system will have many uses in manufacturing and industrial activities. It could be used for quality inspection of manufactured parts, locating parts for automatic operations, aligning parts for assembly, reverse engineering machined parts and documenting as-built assemblies.

Related References:
1. NAVAIR 01-75GAA-3

2. Shaw, M., J. Atkinson, D. Harvey, A. Hobson, and M. Lawler, "3-D Imaging using Projected Dynamic Fringes", SPIE Proceedings Vol. 2340, pp 134-143.

3. Bieman and Rutledge, "3-D Camera", US Patent 6122062, Sept. 19, 2000.

4. "videometrics and Optical Methods for 3D Shape Measurement", Proceedings of SPIE Vol. 4309, Jan 2001.

5. Proceedings of the 3rd International Conference on 3D Digital Imaging and Modeling (3DIM 2001), June 2001. ISBN 0-7695-0984-3, IEEE Computer Society Press.

KEYWORDS: 3-D Measurement, Surface Profile, Dimensional Inspection, Aircraft Control Surfaces

AF03-283 TITLE: Diesel/JP-8 Reformer for Solid Oxide Fuel Cell (5kW-10kW Advanced Portable Auxiliary Power Unit)

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: OO-ALC

Objective: Provide a low-cost, portable, diesel-fuel/JP-8 reformer for a 5kW-10kW solid oxide fuel cell.

Description: The Solid Oxide Fuel Cell (SOFC) is the emerging technology of choice for power generation because of the supreme fuel efficiency, reduced air emissions and minimal fuel costs involved with using SOFC. SOFC requires hydrogen (H2) to operate. Hydrogen provides a relatively simple and efficient fuel source, however, its fuel distribution and on board storage can be problematic.

These problems may be avoided by the use of liquid hydrogen hydrocarbon fuels, such as JP-8 and diesel, but these fuels must be converted to hydrogen by the use of a fuels processor or reformer in order to be utilized by the fuel cell. Fuel reforming technology is needed to transform these available liquid hydrocarbon fuels into commercialization. The development of a low-cost diesel reformer will accelerate the market entry of remote and portable SOFC units. Low cost diesel reforming technology would enable the use of diesel fuel as a H2 source in SOFC and would be advantageous to DOD and commercial markets as well.

Phase I: Conduct research to determine the feasibility of developing a low-cost, reliable diesel/JP-8 reformer suitable for use with commercially developed SOFC (5kW-10kW) for APU and remote applications. Develop specific requirements necessary for the design and development of diesel/JP-8 reformer to meet DOD requirements and deployment goals.

Phase II: Design, develop, test and provide a prototype for a diesel/JP-8 reformer for use with commercially available SOFCs (5kW-10kW). Develop the prototype design into a commercially viable unit, meeting both DOD and industry requirements regarding the use of diesel/JP-8 as a fuel source for 5kW-10kW SOFC.

Dual Use Commercialization Potential: Diesel reforming technology would have abundant use within the military, commercial and industrial sectors.
1. Increased fuel efficiency
2. Reduction in emissions of CO, CO2, NOX, and SOX.
3. Reduction in the use of lead acid batteries
4. A low-cost source of hydrogen for powering fuel cells
5. Utilize existing fuel hydrocarbon infrastructure

Related References:
1. Wyszynski, M.L. and Wagner, T. ¡§Concept Of On-Board Fuel Reforming¡¨, School of Manufacturing and Mechanical Engineering, University of Birmingham, Birmingham, UK, December 1995.

2. Bromberg, L., Rabinovich, A., Alexeev, N., and Cohn, D.R., ¡§Plasma Reforming of Diesel Fuel¡¨, Plasma Science and Fusion Center, Massachusetts Institute of Technology, Cambridge, MA March 1999.

KEYWORDS: Solid Oxide Fuel Cell, Fuel Reformer

AF03-284 TITLE: Nanoscale Devices

TECHNOLOGY AREAS: Electronics, Space Platforms

ACQUISITION PROGRAM: OO-ALC

Objective: Replacing standard integrated cards or functional systems with Nanoscale Devices.

Description: Standard integrated circuits (IC) have limitations or restrictions in size, speed, reliability, complexity and finding suitable replacements for discontinued items. Nanoscale device development and understanding has dramatically grown. Quantum physics properties that quantum computers rely on, is the ability of certain atoms or nuclei to work together as quantum bits. These computing devices are a fraction of the size of typical ICs (nanoscale). Nanoscale devices developed using quantum physics principles have unlimited potential to revolutionize the methods and design of fabricated printed circuit cards and complete systems. They can replace an entire PC board or the set of PC boards that comprise a Line Replaceable Unit (LRU). This would be a good and practical jumping-off point to going direct to the complete device, system or function level. This might include a nanoscale computer (general purpose or flight control), transmitter, GPS receiver, position and/or attitude sensors in either a standalone configuration, or combined within conventional devices (e.g., a nanoscale communications suite (xmtr/rcvr, etc.) encapsulated within the Plexiglas canopy or the control yoke of an F-16 rather than behind the instrument panel or maybe the whole comm suite into the pilot’s helmet. This topic focuses specifically on basic research to replace a standard IC circuit card with a nanoscale device. Although the nanoscale device will be a fraction of the size of a standard sized IC circuit card; the housing of the device should be of sufficient size to support the required I/O pins.

Phase I: Conduct research to determine the feasibility of the methods and strategies for nanoscale device development to replace a circuit card or system. Identify critical technological issues and their impact.

Phase II: Develop and demonstrate prototype methodologies that address critical technological issues to ascertain the feasibility of nanoscale devices that replace existing circuit cards or systems.

Dual Use Commercialization Potential: The technology underlying this topic is quite generic and is applicable to a wide variety of applications and technologies. It is particularly relevant to aircraft and plant maintenance, industrial process control, medical and other applications where system performance is critical and repair should be precise and quick.

Related References:
1. Nanocircuits Coming Soon as Silicon Chips Near Theoretical Limit: Alan Boyle, MSNBC, 24 February, 2000

2. The Incredible Shrinking of the Transistor, NIST

3. Tour, J. et al., J. Phys. Chem. A 1999, 103, pg. 7883

4. Dekker, C. et al.,Science 2001, 294, pg. 1317

5. http://www.asipac.com/EnginesofCreation

KEYWORDS: Nano-Technology, Quantum Physics, Hardware, Software

AF03-287 TITLE: Advanced DC Power Distribution Module--Convert DC to Aircraft Quality Power

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: WR-ALC

Objective: Research and develop an advanced DC power distribution module capable of providing DC power for USAF aircraft.

Description: Currently the Air Force has a growing need for clean, high quality DC ground power to operate aircraft 6 systems during pre-launch, recovery, and maintenance operations. This SBIR will conduct applied research into which technology can meet that need to power aircraft with 270vDC, similar to our existing –60 and –86 Mobile power generators that are used on flight lines. 72kw should be available to a single or combination output of 100V AC single/three phase 60/400 Hz and or 28/270 V DC. Expand on the commercial leaders methods, for portable energy generation that specifically meets the needs of Air Force and Department of Defense yet is flexible enough for commercial use. This level of loading and transient response profiling has never been accomplished nor attempted from fuel cells before. The physical design must meet or exceed the existing platform for an improved and seamless integration this alone is another large technical barrier that must be addressed.

Phase I: Conduct applied research into various power conditioning technologies that meet or exceed the current –60 power generator specifications while analyzing the best source considering battlefield availability. The research must consider mobility, safety, and environmental issues.

Phase II: Develop prototype system to improve design performance, versatility, reliability, and improvements over the current system.

Dual Use Commercialization Potential: Civilian as well as military flightlines use mobile gensets as well as other non-flightline applications where mobile power is required

Related References: MSGT Robert Wertz, AEF Battlelab, http://www.mountainhome.af.mil/AEFB

KEYWORDS: Genset, High Voltage DC, Aircraft Power, Mobile Power

AF03-288 TITLE: Portable Programmable Load Bank

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: WR-ALC

OBJECTIVE: Research and develop a portable programmable load bank that can be used in military as well as commercial aircraft maintenance.

DESCRIPTION: Currently the Air Force is looking for a portable programmable load bank that is capable of evaluating 28.5 to 270 VDC and 60/400 Hz 208 Volt three phase four wire systems. The load bank needs to have programmable step capability of 1kW between 0 to 110kW. It should also have a programmable lagging power factor between 0.8 to 1. This unit should be capable of continuous computer data logging on the unit or through a RS232 or USB port interface to an external computer. The unit should be equipped with an AC Voltmeter (0 – 300 volts), a frequency meter (up to 440 Hz), a power factor meter, an ammeter (0-3000 amps), switching capability to read all three phases, the necessary connection to the existing ground power generator cable head including NSN: 6115-01-389-4093, and the capability to simulate a 28V DC interlocking control circuit found on some aircraft as well as a 28V interlock circuit cable pin. The size of this unit should be as compact as possible but should not exceed 15 feet (4.57 m) in length, 6.5 feet (98 m) in height, and 2500 pounds (lb) (1134 kilograms (kg)) in weight.

PHASE I: Conduct research and design a portable load bank that can test a wide range of flightline generators. This could help the Air Force in reducing our logistical footprint.

PHASE II: Develop prototype system to improve design performance, versatility, reliability, and improvements over the current system.

PHASE III DUAL USE APPLICATIONS: The military as well as the commercial airline market are both considering advanced power solutions to reduce flightline footprints. Having one piece of equipment that could take the place of multiple units or even fill recently developed holes in support due to requirements from new aircraft would help in reducing the logistical footprint.

REFERENCES:
1. The loads required by generators are described in MIL-HDBK-705C
2. "Military Specification Generator Sets, Engine Driven Methods of Tests and Instruction" MIL-STD-705C

KEYWORDS: Load Bank, Portable Load Bank, Generator Tester

AF03-289 TITLE: Advanced Multi-Use Fuel Cell Powered Tactical Vehicle (Tow Tractor) With Distributed Power

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: WR-ALC

OBJECTIVE: Research and develop an advanced electric drive tow tractor with the capability of providing flight-line quality distributive power.

DESCRIPTION: Currently the Air Force has a growing need for multi-tasking capability of its equipment to reduce logistical footprint. This SBIR will conduct applied research into combining electric drive, hydrogen fuel cell and power electronic technology to tow and power aircraft similar to our existing –86 Mobile power generators simultaneously. The tow tractor must meet the parameters of the USAF MB-4 tow tractor (approximately 18,000lb draw bar pull and weigh less than 26,000lbs). 72kw should be available to a single or combination output of 115/208VAC single/three phase 60/400 Hz with the quality and interfacing required to power AF aircraft. This combining the towing capability with this level of loading and transient response profiling has never been accomplished nor attempted from fuel cells before. The physical design must meet or exceed the existing MB-4 and –86 Genset platforms for an improved and seamless integration to which this is another large technical barrier that must be addressed. Integrating this technology into an existing MB-4 flight-line tow tractor platform would help the Air Force in reducing its existing logistical footprint and increase capabilities as well as provide commercial airlines the ability to meet environmental mandates.

PHASE I: Gain knowledge and understand of the new types of fuel cell and distributive power component technologies and using this applied research. Develop a systems integration plan that will allow the technology to demonstrate C2P2 hydrogen fuel cell capability to not only power a tactical vehicle but to deliver 72kW of commercial and/or aircraft quality power once at the destination in phase II. Computer simulations provide significant feasibility and practicality of design and that components are nearly available for manufacturing. Plan should ensure system meets environmental issues, including electromagnetic interference, safety, and possesses a lower life cycle cost than current configurations.

PHASE II: Develop prototype system to improve past USAF hybrid MB-4 design performance while increasing versatility, reliability and improvements over the current systems through multi-tasking and hydrogen fuel cell applications.

PHASE III DUAL USE APPLICATIONS: This technology could provide an almost pollution free source for the commercial airline sector and other government agency use. The Army has proven a substantial logistic footprint reduction with distributive power while AEF C2P2 study indicates a reduction in logistic trail through a modular fuel cell power source. This advanced technology demonstration would not just benefit the Air Force but DoD and industry as a whole.

REFERENCES:

1. This site contains the information provided by AEF Battlelab's initiative to demonstrate such a system. http://www.mountainhome.af.mil/AEFB/initiatives/exec_summaries/C2P2.doc

2. This site has information available within it regarding a multitude of issues with respect to fuel cell power on vehicles. http://www.futurecarcongress.org/

3. This site gives some basic information about alternate fuels and alternate power on vehicles. https://www.futuretruck.org/technologies/index.html

4. This site provides information on the Army's initiatives toward tactical vehicles that would benefit from this development while providing the AF with a specific but DoD applicable platform. http://www.tacom.army.mil/tardec/nac/projects/home.htm

5. This site explains DoE's initiative for distributed power and hydrogen use http://www.nrel.gov/hot-stuff/press/2001/0201_dist.html

KEYWORDS: Fuel Cell, Distributive Power, Tow Tractor

AF03-290 TITLE: High Density Hydrogen Storage

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: WR-ALC

Objective: Research and develop innovative methods to store high density hydrogen on-board vehicles and ground support equipment using a metal hydride, cryogenic hydrogen, or other innovative technology such as graphite nano fibers.

Description: A major drawback to using hydrogen to power a fuel cell is storage procedures. Current methods of storing hydrogen in a gaseous or liquid form do not offer the energy density of conventional gasoline per unit volume. This leads to a host of problems. The goal of this SBIR project is do applied research that will gain knowledge and understanding necessary to produce a useful method to store Hydrogen using a high-density hydrogen medium. The medium will be deployed on a vehicle or ground support equipment to power a fuel cell and should strive to provide comparable energy density per unit volume to gasoline. The technology must also demonstrate a reasonable re-fuel rate.

Phase I: Research will determine which medium will result in the desired energy storage density. Integration of this technology to the ground support equipment must also be explored. The study will investigate existing gravimetric, volumetric and refueling parameters with improved storage performance parameters.

Phase II: Develop a prototype storage unit using the technology to produce the desired energy storage density and other parameters.

Dual Use Commercialization Potential: The storage device would provide a leap forward in providing a commercialized fuel cell power generation for aviation and other transportation industries. While fuel cells are coming at a rapid rate, we must be ready with the technology to provide for their fuel.

Related References: MSGT Robert Wertz, http://www.mountainhome.af.mil/AEFB

KEYWORDS: Fuel Cell, Hydrogen, Electric Vehicles, Support Equipment

AF03-291 TITLE: Bio-Mass Waste Water Generator/Gray Water Purifier

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: WR-ALC

Objective: Research and develop a bio-mass fueled water purification system based on solid oxide fuel cell/ JP-8 reforming technology.

Description: Currently the Air Force is looking into all options of reducing its logistical footprint. Solid oxide or molten carbonate fuel cells may possess the capability to be fueled by bio-mass and supply a drinking quality water stream.

Phase I: Conduct applied research into the requirements of a bio-mass feed and for the purified water exhaust stream. The research must consider all safety and environmental issues where a high efficient system uses minimal logistical fuel while recovering waste to support battlefield requirements.

Phase II: Develop prototype system to improve design performance, versatility, reliability, and improvements over the current system.

Dual Use Commercialization Potential: The military as well as the civilian market will be shifting to fuel cell technology in the future and this concept could help in developing more options for the fuel cell specifically in remote rural locations with barren landscapes.

Related References: http://resourcesnews.tripod.com/Biomass-gas.htm

KEYWORDS: Solid Oxide, Molten Carbonate, Bio-Mass, Palatable Water, Fuel Cell

AF03-292 TITLE: Cold Turbine Engine

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: WR-ALC

OBJECTIVE: Research and develop a multi-fueled power generator configuration and requirement for multiple AF weapon systems weapon systems.

DESCRIPTION: Currently the Air Force has a growing need for clean support equipment and vehicles. This SBIR will conduct applied research into a multi-fueled (diesel/JP-8 mandatory) high power density power plant to be integrated into a bomb jammer (MHU-83) platform with the possibility of upgrading it to hydrogen powered in the future. The current 30HP diesel engine is contained within a compartment with dimensions of 40.6’’ (length) by 27.75’’ (height) by 17.33’’ (width) which the new hybrid electric power plant should be constrained to these also to feed into the system load and energy storage device. This unit should also have the possibility of providing 15kW of 110/208Vac 60/400Hz of distributive power. It must exceed environmental, efficiency, maintenance and performance expectations of engine standards for 2007. A load profile will be available in August of 2003.

PHASE I: Conduct applied engine technologies that meet or exceed the current diesel emission standards, reducing thermal and aural signatures while increasing the horsepower to weight ratio and minimizing volume. The research must consider mobility, safety, and environmental issues.

PHASE II: Develop prototype system to improve design performance, versatility, reliability, and improvements over the current system.

PHASE III DUAL USE APPLICATIONS: Civilian as well as military flight-lines use mobile generators as well as other non-flightline applications where mobile power is required. Current diesel non-road engines are large sources of air pollution and impending regulation from EPA will force both civilian and military to clean up.

REFERENCES: No web sites available but questions can be directed to the MMHE Customer Service Representative SMSgt. Dale Stokes WR-ALC/LESVG (478) 926-7603 ext.114. e-mail: dale.stokes2@robins.af.mil

KEYWORDS: Genset, Cold Turbine, Aircraft Power, Mobile Power

AF03-293 TITLE: Advanced Hydrogen Transfer Sensor Research

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: WR-ALC

OBJECTIVE: Research the feasibility of emerging electric drive technology based on Air Force vehicle fleet needs and operational parameters that demonstrate that new technology can meet these needs.

DESCRIPTION: Perform initial applied research to gain knowledge and understanding with follow on technology demonstration to provide the next step in hydrogen distribution. The focus of the applied research is to gain knowledge on various types of new hydrogen transfer technologies currently being developed. The system should have a long in-service life, low cost, high reliability, and a sensor system to prevent contamination of a storage system. The transfer system should portable and able to service near atmospheric pressure hydrogen system to/from vessels up to at least 5000psi to include but not limited to carbon fiber and metal-hydride hydrogen storage systems. Combine hydrogen sensors with various analytical equipment to ensure hydrogen powered vehicles and equipment have no leaks or flaws. Transfer rate should be equivalent to 150scfm @ 5000psi but able to identify the maximum safe rate of either system involved in the hydrogen transfer. The Air Force is preparing to invest in a hydrogen infrastructure and will need to ensure safe/efficient hydrogen transfer.

PHASE I: Gain knowledge and understand of the new types of hydrogen technologies/applications and using this applied research, develop a systems integration plan that will allow the technology to be demonstrated in phase II. Computer simulations and cost benefit analysis should provide significant feasibility and practicality of design that components are nearly available for manufacturing. Plan should include life cycle cost.

PHASE II: This demonstration phase will showcase the performance parameters discovered during the applied research phase will meet Air Force needs in the commercial/tactical vehicle fleets.

PHASE III DUAL USE APPLICATIONS: This technology could insure safe operation of hydrogen powered transportation for commercial and government use. Since the President announced his emphasis on hydrogen powered vehicles, this advanced technology would not only benefit the Air Force but DoD and the nation as a whole.

REFERENCES:

http://www.energy.gov/HQPress/releases01/maypr/chapter6.pdf pages 10-11
http://www.eren.doe.gov/hydrogen/pdfs/mp27770.pdf page 8

KEYWORDS: Hydrogen, hydrogen storage, fuel cells, reformers